THE ENGINEER

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Electricity Supplies Next Winter

Last week the Electricity Sub-Committee of the Joint Consultative Committee of the National Joint Advisory Council issued its report on the measures necessary for spreading the industrial electricity load in the coming winter. The recommendations in this report, which has been accepted by the Government, are based upon a report given by the British Electricity Authority on its experience last winter and its estimates of the position during the coming winter. The position is considered to be more serious than any with which the sub-committee has had to deal since 1947. It is pointed out that although new generating plant is being brought into operation on an ever increasing scale the excess of demand over supply continues to grow. Estimates indicate that, even after allowances have been made for frequency and voltage reductions, there will remain an overall deficit of from 1200MW to 1300MW in average cold weather during the coming winter, and this deficit must be either spread or shed. As industry alone cannot hope to spread such a deficit there must be full co-operation of domestic and commercial consumers as well as industrial users of electricity. This co-operation is one of the primary recommendations made in the report, which also says that industry should strive by load-spreading measures to effect at least a 20 per cent reduction of its maximum demand that would have been made in 1950–51 had there been no reduction by load spreading. The object is to achieve a reduction of 600MW in national simultaneous maximum demand. It is also recommended that the hours to which load spreading measures should apply for all classes of consumer should be from 8 a.m.-12 noon and 4 p.m.-5.30 p.m. from November 1, 1951, to March 31, 1952. In order to achieve the required results it is recommended that full advantage should be taken of the possibility to secure a reduction of maximum demand by an adjustment of the customary hours of work, and that no obstacle should be placed in the way of firms wishing to install or make increasing use of auxiliary generating plant. In the recommendations an exception is made in the case of Scotland, where new steam plant and additional supplies from hydro-electric sources will considerably reduce the deficit as compared with last winter.

The Late Mr. Ivor Williams

We have learned with regret of the death of Mr. Ivor Williams, of Llandaff, Cardiff, which occurred in London on August 8th, following an operation. Mr. Williams, who was seventy-four, was particularly well-known in colliery engineering circles and had been for many years chief engineer of Powell Duffryn, Ltd. He was born at Ystradgynlais in 1877, and after leaving school was apprenticed at the Fraser and Chalmers Engineering Works, Erith, Kent. On the completion of his apprenticeship Mr. Williams worked for a time for Crompton and Co., Ltd., Chelmsford, and subsequently went to South Africa, where he was engaged principally in the installation of winding engines. He returned in 1904 to become assistant engineer in South Wales to the Powell Duffryn Steam Coal Company, Ltd. After three years in that post, Mr. Williams was appointed engineer to the Penrhiwceiber Colliery Company. He left in 1910 to supervise the sinking of the Bedwas Colliery for the Bedwas Navigation Company. Two years afterwards, Mr. Williams rejoined the Powell Duffryn Steam Coal Company, Ltd., as engineer of the Rhymney Valley collieries, becoming subsequently chief engineer of the company, a post which he continued to hold on the amalgamation, in 1935, of Welsh Associated Collieries, Ltd., and the Powell Duffryn Steam Coal Company, Ltd., to form Powell Duffryn Associated Collieries, Ltd. Upon the nationalisation of the coal mining industry in 1947, Mr. Williams remained with the reconstituted Powell Duffryn, Ltd., as chief engineer. He was a director of the Rhymney Engineering Company, Ltd., and the Bedwas Building Company and was a member of the council of the South Wales Institute of Engineers.

Hydro-Electric Board Appointments

Several new appointments and reappointments to the North of Scotland Hydro-Electric Board have been made by the Secretary of State for Scotland and the Minister of Fuel and Power. Mr. Tom Johnston, the present chairman, and Mr. Neil Beaton, whose current terms of office expire in September, have been reappointed, and Sir Hugh Mackenzie of Inverness, at present a member, has been appointed deputy chairman in place of the late Sir Edward MacColl. Three new members have also been appointed as from September 1st. They are Mr. E. S. Harrison, ex-provost of Elgin, a director of James Johnston and Co., Elgin, and one-time chairman of the Local Authorities Hydro-Electric Committee; Mr. William Leonard, formerly Labour M.P. for the St. Rollox Division of Glasgow, and a member of the General Council and former President of the Scottish T.U.C.; and Mr. A. I. Mackenzie, C.A., a partner of Brown, Fleming and Murray, Chartered Accountants, Glasgow. All the members of the Board, including the chairman and deputy chairman, will, in future, serve on a part-time basis.

Ministry of Works Report, 1950

The annual report of Ministry of Works, 1950, has now been published. It shows that the output of the building and civil engineering industries in Great Britain for the year was valued at £1307 million and that during this period licences were issued for a total value of over £240 million. The report states that although the production of bricks rose to 5921 million and that of cement to over 9¾ million tons, the highest recorded production, neither production was sufficient to meet all demands. Shortage of labour was stated to be the main limiting factor in production, although the production of other building materials was affected mostly by shortages of raw materials. Exports of building materials, cement and glass being the most important, amounted to £20 million, and exports of building fitments reached £18½ million. In dealing with price controls, the report indicates a general 8 per cent rise in the price of building materials. The wide sphere of building activities within which the Ministry was engaged during the year is reviewed. Work on new research and production buildings for the Ministry of Supply and the Department of Scientific and Industrial Research exceeded £11 million during 1950. Two new atomic energy establishments at Capenhurst and Aldermaston were started, one of the atomic piles at Windscale, Cumberland, was completed, and further work was carried out at Harwell. A large wind tunnel at the National Aeronautical Establishment, Bedford, and another at the Royal Aeronautical Establishment, Farnborough, were also finished during the year.

National Fuel Policy

In a recent statement by the Minister of Fuel and Power, Mr. Philip Noel-Baker, it was announced that a committee had been established to consider in the light of technical developments whether any further steps could be taken to promote the best use of fuel and power resources in this country. The Minister stated that in the five years before the war the average internal consumption of coal in the United Kingdom was 178 million tons a year. In 1950 it was over 202 million tons, in spite of the fact that the household market had less, and this year might reach 210 million tons. The electricity sent out by the British Electricity Authority was now 50 per cent more than it was in 1946, whilst the gas supply had increased by 25 per cent in the same five years, and the oil used had increased by 90 per cent. The following have been invited to serve as members of the committee: Mr. Lincoln Evans, General Secretary of the Iron and Steel Trades Confederation; Mr. N. W. Gardiner, technical director of Huntley and Palmers, Ltd.; Sir Claude Gibb, F.R.S., chairman and managing director of C. A. Parsons and Co., Ltd.; Professor W. R. Hawthorne, Professor of Applied Thermodynamics at Cambridge University; Professor W. A. Lewis, Professor of Political Economy at Manchester University; Mrs. M. Mackintosh, Tutor in Sociology at Bedford College, University of London, Member of the London County Council; Miss M. R. Schofield, housing manager of Stoke Newington Borough Council.

Advisory Committee on Metals Economy

It was announced on Monday last that the Minister of Supply, in conjunction with the Minister of Materials, had appointed an Advisory Committee on Metals Economy to help in ensuring the most economical use of metals in the engineering industry and in the defence programme. Mr. D. A. Oliver, director of research to the B.S.A. group of companies, who has recently become metals economy adviser to the Minister of Supply, is chairman of this new committee, which includes members drawn from industry and Government departments. The industrial members are Dr. G. L. Bailey, British Non-Ferrous Metals Research Association; Mr. H. A. R. Binney, British Standards Institution; Mr. H. H. Burton, English Steel Corporation, Ltd.; Mr. W. C. F. Hessenberg, British Iron and Steel Research Association; Mr. E. W. Grinham, Standard Motor Company, Ltd.; Dr. Ivor Jenkins, General Electric Company, Ltd.; Dr. L. B. Pfeil, Mond Nickel Company, Ltd.; and Dr. C. J. Smithells, British Aluminium Company, Ltd. Mr. K. M. McLeod, of the engineering industries division, Ministry of Supply, is the secretary of the committee. The committee's terms of reference are "to bring under review, in consultation with the various Government and industrial authorities concerned, ways of economising in the use of scarce metals in the design, specification and the manufacturing processes of metal goods for both re-armament and civil purposes, and to advise the Government how it can best assist in promoting such developments."

No-Load Pneumatic Transients in Air Blast Circuit Breakers

By K. K. SCHILLER, Ph.D., A.Inst.P.*

THE two main types of circuit breaker in use are the old-established oil circuit breaker and the air blast circuit breaker developed during the last ten or twenty years. Both kinds of breaker use as an interrupting medium high-pressure gas to cool and de-ionise the arc forming between the separating contact parts. In the oil circuit breaker the arc is drawn under oil. The heat produced vaporises and breaks up the oil in the immediate neighbourhood, thus surrounding the arc with a gas bubble consisting of the decomposition products. Due to the extremely rapid generation of the gas and the inertia of the surrounding unvaporised liquid which cannot recede quickly enough, the pressures in these gas bubbles are very high. Modern circuit breakers, moreover, are usually fitted with arc control devices which utilise this pressure to create jets directed across or along the arc. The quenching ability of such breakers is therefore directly dependent on the current to be interrupted.

Air blast breakers, on the other hand, rely for their quenching ability on compressed air which is stored in receivers forming an integral part of the breaker unit. During interruption, compressed air from the receiver is directed to the interrupting contacts which are located in, or consist of, suitable nozzles. In these nozzles the pressure of the air flowing through them is gradually reduced to atmospheric and this air, laden with the arc products, is brought to an exhaust.

The energy stored in the compressed air is also used to operate the breaker mechanically. In this way the contacts are opened with high acceleration, and operation in the absence of the quenching medium is made impossible.

The processes of circuit interruption and isolation are usually separated in modern air blast breakers, by having an isolator which opens automatically after circuit interruption. This isolator is operated pneumatically, after successful interruption. The main contacts then close again. It will be seen that the interrupting mechanism is in no way dependent on the current to be interrupted. The operation of this type of breaker depends in every respect on the quick, sufficient, and reliable supply of compressed air to the interrupting chamber, both for the mechanical operation of the contacts and for the ensuing extinction of the arc.

As circuit breakers are built to deal with the essentially transient phenomena of switching, a peculiar combination of gas-dynamic and electro-dynamic problem arises. Here we shall discuss one aspect, namely, the processes involved in getting the compressed air from the receiver to the interrupting contacts. Increasing interest in these pneumatic processes has been apparent by a number of papers on the subject which have appeared in the technical Press during the last few years. Although transient effects are known to exist the processes are often assumed to be steady.[1] Yet, taking the supply pipe lengths of a breaker as of the order of several feet, while the speed of sound is of the order of 1000ft per second, it is clear that the pressure build up in the breaker will be measured in half cycles (0·01 second), i.e., in times of the same order of magnitude as the interrupting process itself. The transient processes which actually occur are by no means simple, even in relatively simple geometrical conditions, involving expansion, compression and shock waves, their reflections and associated phenomena. The first purely academic and theoretical investigation of such gas-dynamic processes were made by B. Riemann[2] as far back as 1860. Researches on these non-linear waves have been continued at an accelerated rate during the last decade or so. The practical applications have been found, so far, in vacuum brakes and internal ballistics, as far as the one dimensional theory is concerned which is capable of giving most of the answers required by the air blast breaker designer.

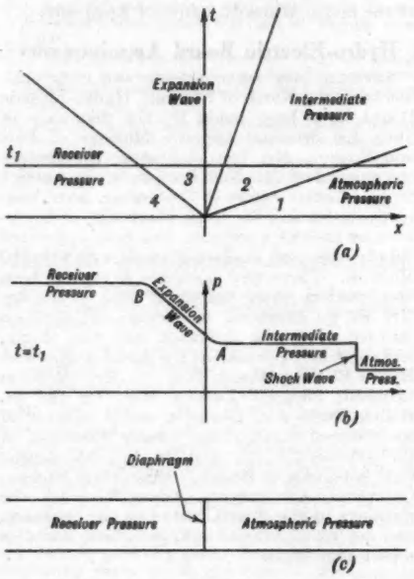

FIG. 1

In the following treatment we shall first consider theoretically simplified models of a single-phase air blast breaker and then compare the results with those of tests performed on a similar experimental arrangement, which is shown in Fig. 8. Its details are discussed later in this article.

THEORETICAL CONSIDERATIONS

Riemann's Investigations.—A brief discussion of an example of Riemann's paper will show the sort of phenomena we have to expect.

The problem discussed is this: consider a straight pipe of infinite length and constant cross section which is filled with gas; a diaphragm divides the pipe into two halves and it is assumed that the pressures on the two sides are not the same. To fix ideas, let the pressure on the right side be atmospheric, while the one on the left side is very much higher; let it be called receiver pressure—see Fig. 1 (*c*). At a certain moment the diaphragm is suddenly removed, releasing the compressed gas which flows into the low-pressure column. A detailed description of the ensuing processes of pressure equalisation is required.

Let

u = speed; ρ = density; κ = ratio of specific heats = 7/5 = 1·4 for air; p = pressure, M = a constant.

Then the equation of motion in one dimension is:

$$\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}=-\frac{1}{\rho}\frac{\partial p}{\partial x} \quad . \quad . \quad . \quad (1)$$

The equation of continuity is:

$$\frac{\partial \rho}{\partial t}+\frac{\partial}{\partial x}(\rho u)=0 \quad . \quad . \quad . \quad . \quad (2)$$

The equation for adiabatic changes in gases is:

$$p=M^2\rho^\kappa \quad . \quad . \quad . \quad . \quad (3)$$

Equation (3) holds wherever the flow is isentropic. Riemann uses it throughout, but Rankine and Hugoniot have shown that shock waves, which, as we shall see, occur in our problem, are not isentropic, and therefore (3) must be replaced by

$$\frac{1}{2}(p_1+p_2)\left(\frac{1}{\rho_1}-\frac{1}{\rho_2}\right)=\frac{1}{\kappa-1}\left(\frac{p_2}{\rho_2}-\frac{p_1}{\rho_1}\right) \quad . \quad (4)$$

in which the subscripts (1) and (2) refer to the two sides of the shock. This means that the change of internal energy suffered by the gas crossing the shock front is equal to the work done by the average pressure in compressing the gas. If the shock is small, i.e., if the two pressures differ little, equation (4) becomes identical with equation (3).

The resulting flow can best be described in diagrams. The pressure distribution shortly after the diaphragm is removed is shown in Fig. 1 (*b*). A shock wave of a pressure intermediate between the receiver pressure and atmospheric pressure runs into the space filled by static atmospheric air. In the neighbourhood of the diaphragm an expansion wave forms, which connects the region of the intermediate pressure behind the shock front with the high pressure in the receiver. The head of this expansion wave *B* is moving into the receiver initiating the drop in the pressure there, while its tail *A* follows the shock front, though never catching up with it, moving with a smaller velocity. If the receiver pressure is less than a certain critical pressure the tail would also run into the receiver like the wave head *B*, which always does so.

The course of these processes in time is best shown in a time diagram, Fig. 1 (*a*), taking the distance x from the place of the diaphragm along the tube axis as abscissa and the time t as ordinate. As the diaphragm is removed the shock wave races into the atmospheric air, the path being shown in Fig. 1 (*a*) as the line that divides the atmospheric static area in sector 1 from the air under constant intermediate pressure in sector 2. This intermediate pressure is higher than the atmospheric pressure in front of the shock wave, but much less than the pressure in the receiver. The transition between this intermediate pressure and the receiver pressure is formed by a simple expansion wave existing in sector 3.

Sector 4, finally, represents the area not yet reached by the receding expansion wave. Sectors 2 and 3 show the spreading of the pressure-equalisation process, while sectors 1 and 4 represent the parts which are not yet affected.

The shock wave racing into the atmospheric air is (neglecting viscosity and heat conductivity) a sharp discontinuity of pressure, density, temperature, particle speed and entropy. The speed of the shock wave (which is not to be confused with the speed of the gas particles) is always supersonic with respect to the air in front of it. This high speed is the physical reason for the

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abruptness of these changes, because the gas in front of the wave cannot be "warned" of its approach, since signals would only run with the speed of sound. If viscosity and heat conductivity are taken into account the thickness of the shock wave can be estimated to be of the order of 0·0001in. This is not much more than the mean free path length of the gas molecules. From the point of view of the macroscopic theory the change is therefore correctly described as sudden.

Riemann has given all the necessary formulæ to calculate the intermediate and

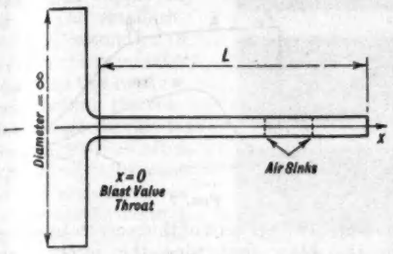


FIG. 2

expanding states on the basis of the given initial conditions.

A completely straightforward, but laborious, calculation leads to the following equation for the intermediate pressure p':—

$$R^{0.4}(6+P)^{0.4}(1+6P)+(1+6P)^{1.4}-2R^{0.2}(6+P)^{0.2}(1+6P)^{1.2}=5B(P-1)(6+P)^{0.4} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where we have used for brevity

$$\frac{\rho_1}{\rho_2}=R,\ \frac{p'}{p_2}=P \text{ and } p_2(\kappa-1)^2/4M^2\kappa\rho_2^{\kappa}=B \quad . \quad . \quad . \quad . \quad . \quad (6)$$

The meaning of the other symbols can be taken from the various figures. Both R and B are known. Equation (5) can, of course, only be solved by trial and error, and when an approximate solution has been found Newton's Regula Falsi, or a similar method, can be used to obtain more accurate solutions. For $R=20$ and 11 the solutions are found to be $P=6\cdot2$ and $4\cdot0$ respectively.

Effects of Large Volume Air Receiver and Finite Length of Air Passages.—Now, in fact, the arrangements of an air blast circuit breaker are very different from this model. Its receiver, which contains the compressed air, is of much larger cross-sectional dimensions than the pipe work leading to the interrupting chambers. Moreover, the interrupting chambers are, of course, not open to atmosphere (except through the contact nozzles), so that the pipe has now to be considered closed at a certain distance from the diaphragm. This closed end will create reflections of the out-running shock wave which will prove of very great importance for the understanding of the building up of the pressure under the circumstances of the model considered, which represents the theoretical optimum for the designer. We consider, therefore, as a next approximation, a model of the shape given in Fig. 2. In the place of the diaphragm a blast valve will be assumed.

Clearly, if the receiver diameter is regarded as infinitely large compared with the pipe diameter, the air loss through the open blast valve cannot produce a pressure drop in the receiver. This would require the front of the expansion wave, in Fig. 1 (*a*), to coincide with the *t*-axis. The pressure would then be permanently constant to the left of the blast valve. Now, as is shown in treatises on gas dynamics, the speed of the head or tail of a simple expansion wave is always the local sound velocity superimposed on the speed of the gas particles. For instance, at the head of the expansion wave the speed of the gas particles is 0 (the gas is altogether static in sector 4—Fig. 1 (*a*)—and the slope of the line separating sectors 3 and 4 is, therefore, $-a_1$, the sound speed corresponding to the gas in the receiver, the — sign indicating the direction.

If this line is to be vertical it is only necessary to assume the speed in sector 4 to be equal to a_1 instead of 0; the speed of the expansion wave head is then $a_1-a_1=0$, i.e., it "stays put" in the valve, the air speed there being equal to the sound speed. This is just what happens in the narrowest section in the valve, provided only that the pressure ratio between the two sides is above the critical value. Now, therefore, we specify more accurately that $x=0$ should represent the narrowest cross section of the flow in the pipe, which should, moreover, be the same as the pipe cross section. The pressure there is not the receiver pressure, but, as always in a nozzle throat, only 52·8 per cent of it.

At $x=L$ (Fig. 2) the pipe is closed. The shock wave coming from the receiver is reflected as shown in Fig. 3. The reflected and receding shock wave leaves a column of static air behind. Its pressure p_2 can be very high and is not determined (as is the case with linear waves such as electrical surges) by a simple doubling effect; the relation for such shock reflections is :

$$\frac{p_2-p_1}{p'-p_2}=1+\frac{1+\mu^2}{\left(\frac{p_2}{p'}\right)+\mu^2}\dagger \quad . \quad . \quad (7a)$$

where

$$\mu^2=\frac{\kappa-1}{\kappa+1}=\frac{1}{6} \text{ for air,}$$

p_1 = atmospheric pressure,
p' = pressure of incident shock wave (intermediate pressure).

For small shocks, i.e., $p_2/p'=1$, the pressure approximately doubles, but it will be seen that if p_2/p' is small,

$$\frac{p_2-p_1}{p'-p_2}=2+\frac{1}{\mu^2}=8 \text{ for air} \quad . \quad . \quad (7b)$$

The pressure increases can therefore be enormous. It should be noted that the

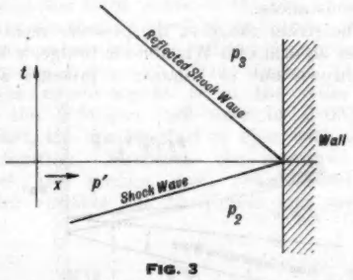


FIG. 3

pressure created by the receding shock wave need, by no means, be equal to the receiver pressure p_1. When this shock has reached the blast valve the pipe is filled with static air of pressure p_2. Depending on the relation between the receiver pressure p_1 and p_2 a new expansion or shock wave would return into the pipe, and this process of outgoing and returning waves would go on until the receiver pressure was reached assymptotically in the whole system. In fact, however, there are the air losses through the interrupting nozzles and the drop in the receiver pressure due to the necessarily finite receiver volume, so that in practice equilibrium is more or less reached at the first return of the shock wave.

Interrupting Nozzles as Air Sinks.—The interrupting nozzles which are situated near the closed end of the pipe (see Fig. 2) can be regarded as air sinks of given strength depending on the choking effect of the arc. These sinks may be inactive below a certain critical pressure and work above it. It will be seen that this is the case with "Duo-Blast" nozzles with which the experiments described below were performed. The critical nozzle pressure is the one which opens the interrupting nozzles of the breaker. As we have just seen, the reflected shock wave leaves a column of static air of pressure p_2 behind; this pressure is taken to be above the critical nozzle pressure and, therefore, finds the sinks active. Their strength

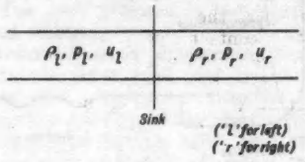


FIG. 4

is to be regarded as small, so that the pressure drop of the surrounding static air is also small.

The action of air sinks follows from the following equations; in general, there will be different values of density, pressure and speed on the two sides of the sink (see Fig. 4). The equation of continuity demands that

$$u_l\rho_l=u_r\rho_r+Q \text{ (Q being the strength of the sink)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

the conservation of momentum requires that

$$p_l-p_r=u_r^2\rho_r-u_l^2\rho_l \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

and the adiabatic relation requires that

$$p_l\rho_l^{-\kappa}=p_r\rho_r^{-\kappa} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

It is easily seen that

$$\rho_l=\rho_r=\rho$$
$$p_l=p_r=p$$
$$-u_l=u_r=u \quad . \quad . \quad . \quad (11a, b, c)$$

satisfy equations (8) to (10). Equation (11c) implies that the air flows equally towards the sink from either side in originally static air. An instantaneous picture of the pressure distribution when the reflected shock wave has travelled back about half the way to the receiver is shown in Fig. 5.

Consequences of Finite Blast Valve Piston Inertia.—So far our considerations have still been based on the assumption that we have a massless blast valve piston which can operate instantaneously. This is, of course, an unrealisable ideal, and the difficulty (as yet unsolved) of speeding up sufficiently the blast valve action has some very serious consequences. Instead of a sharp compression shock leaving the blast valve on opening, a simple compression wave emerges, which, being unstable, forms a shock wave only later.[4] In fact, the shock wave is usually formed after the reflection so that the advantage of exceptional pressure build up according to equation (7*a*) is lost. Since, as can be shown,‡ according to a fundamental theorem of gas dynamics, only simple compression or expansion waves can run into static air, it will be such a simple compression wave that is reflected, as shown in Fig. 6. In the region between $x=X$ and $x=L$ there is an interpenetration of the oncoming and reflected compression wave; there is therefore no intermediate pressure formed in this part of the air system. The pressure will rise smoothly from the atmospheric p_2 to p_3. This p_3 cannot, however, be calculated according to equation (7*a*), and it corresponds usually to little more than a doubling effect. Nevertheless, the wave front is so steep that the pressure shock is formed shortly afterwards. The interpenetration

† See Bibliography,[3] page 153.

‡ See Bibliography,[3] page 61.

such as takes place between X and L is rather involved.§

It may be useful to consider qualitatively the pressure at the nozzles under no-load conditions as they occur with a "slow" blast valve, and with an ideal "quick" blast valve (see Fig. 7). The relative pressures are drawn approximately as they would be for an intermediate pressure p' of about 100 lb per square inch and a receiver pressure of 300 lb per square inch. Under

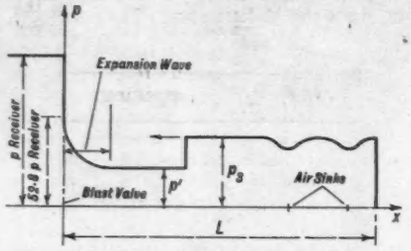


FIG. 5

actual conditions the choking effect of the arc would largely prevent the indicated pressure drops.

The lower curve a shows the slow action (see also two top curves, Fig. 1). We note a smooth rise of pressure followed by a relatively slow drop due to nozzle losses. With a quick-acting blast valve (curve b) the pressure rise at the nozzle is initiated earlier (due to the speed of a shock wave being greater than that of a continuous wave). Shortly after rising to the intermediate pressure p' the pressure jumps to the reflected pressure level p_3, at A (because of the near closed end of the air system). The pressure will then drop only slightly due to the losses through the nozzles; a more pronounced pressure drop will begin at B, when the head of the expansion wave, now coming from the receiver end, arrives at the nozzle. By this time, however, the arc ought to be quenched. As mentioned above, the choking effect of the arc would largely prevent these pressure drops, as is experimentally proved by load tests corresponding to curve a, provided only that the nozzle throat is small relative to the air passages. This point can be estimated very roughly as follows:—

Take as the volume available for one "Duo-Blast" nozzle about 600 cubic inches and a throat area of $2\times1=2\text{in}^2$. The air lost through it, in $^1/_{100}$ sec if there is no arc, will be $0{\cdot}01\times12{,}000\times2=240\text{in}^3$, taking the speed of sound to be approximately 12,000in per second.

As the pressure in the throat of a nozzle is only about half the entry pressure, this value corresponds to 120 cubic inches in the chamber of 600 cubic inches. Hence, the pressure drop would be in the order of 20 per cent on no load. The arc will tend to reduce this figure considerably.

Experimental Studies

Test Arrangements.—To check the above investigations experimentally, the single-phase test arrangement shown in Fig. 8 was subjected to no-load tests. The arrangement consists essentially of three portions: a vertical air receiver with incorporated blast valve, an assembly of two interrupting chambers mounted on top of each other, and a connecting blast feed pipe about 95in long. The air receiver has a volume of about 9 cubic feet. The valve e connecting it to the blast feed pipe has its entrance entirely in the bottle.

A slightly bent portion of the valve tapers down to the bore of the blast feed pipe. The other end of the pipe is fitted to a casting which changes the cross section of the air passage from circular to ring shaped. The next portion, within the lower porcelain insulator, carries the air through a more-or-less constant ring-shaped cross section of roughly the same area as the feed pipe up to the lowest pair of "Duo-Blast" interrupting nozzles[6] which are again housed in a casting which is clamped to the insulator. Another casting is mounted on top of this one and is followed by the top interrupting chamber, again within a porcelain insulator. The exhausts from the interrupting nozzles are part of the castings forming the top and bottom of the interrupting chambers.

The pressure test points were chosen, where possible, in the positions of intrinsic interest which were most likely to confirm or refute the above theory. Thus, one hole a was drilled into the wall of the blast valve to test the pressure build up adjacent to the receiver. The next two points were chosen in the blast feed pipe, one, b, 4½ft above its lower end, and the other, c, 1ft below its upper end. The former should show pressure effects unaffected by any influences at the end.

In the double head arrangement itself, the choice of testing points was limited to the castings. A hole d was drilled through the wall at the level of the lower interrupting nozzles. Lastly, a test hole e was provided in the casting just below the top chamber.

The pressure-measuring element was a Collin's pressure indicator, adapted for electronic recording by mounting a strain gauge on the main pressure spring. The damping of this instrument was not all that might have been desired so that the resulting oscillograms show some slight parasitic superimposed vibrations (Fig. 9).

It should be noted, however, that in all the tests the crucial evidence consists of the qualitative shape of the pressure curves, e.g., the existence of an outrunning wave of relatively low pressure, the existence of shock waves, the relative timing of pressure peaks at different points of the air passages, &c. The time required to perfect the instrument was not justified, therefore, under the circumstances.

The strain gauge of the pressure recorder forms an arm of a Wheatstone bridge, which is thrown out of balance if pressure acts

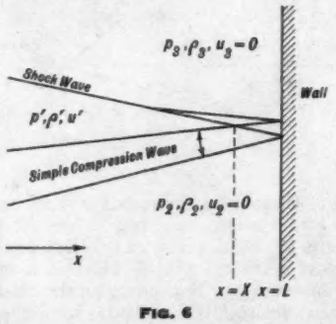


FIG. 6

on the instrument. The bridge voltage, after being amplified, is applied to the vertical deflection plates of a cathode-ray tube. The phenomena being of a transient nature, the beam was not deflected horizontally and the pressure time curve was produced by the motion of the film at given speed.

Test Results.—Several test series under varying conditions were performed. Some representative results are given in support of the theoretical investigation.

In Fig. 9 we reproduce oscillograms a–e obtained at the corresponding points indicated in Fig. 8. Starting with a, the one corresponding to the blast valve, we see that the pressure first rises to an intermediate pressure and is then suddenly raised to the peak pressure by the return of the reflected shock wave.

The next two oscillograms, b and c, taken within the blast feed pipe, are very similar; they both show again a smooth rise to an intermediate pressure which is raised to the peak by the returning shock wave. The intermediate pressure here, however, is lower, while the jump of the returning shock is higher than in the blast valve. The test point in the blast valve is very close to the smallest section of the air flow where the

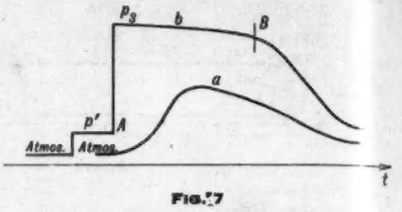


FIG. 7

pressure is 53 per cent of the receiver pressure. In the blast feed pipe the intermediate pressure corresponds to our pressure p', which is much less than half the receiver pressure (see Fig. 5). On the other hand, the returning shock wave loses in strength in passing through the varying cross section of the blast valve. It is also due to this varying cross section of the blast valve that the intermediate pressure p' in the feed pipe is different from the value one would obtain if the cross section were constant throughout. This converging portion raises the intermediate pressure in the blast feed pipe and is therefore of the utmost practical importance.[5]

The oscillograms taken in the interrupting chambers show no intermediate pressure level; instead, there is a smooth rise to the peak. Here we are in the region of interpenetration between the incoming and reflected simple compression waves (see Fig. 6).

All the tests reported here were taken with a receiver pressure of 300 lb per square inch gauge. A similar test series with a 150 lb per square inch gauge gave corresponding results.

It is of interest to note that the pressure peaks are practically the same in all positions. Pressure losses due to friction are practically negligible. The pressure peaks reached depend mainly on the intrinsic mechanism of the building up of pressure at the position considered and are theoretically everywhere the same (see Fig. 6).

General Observations and Conclusions

As we have already pointed out, the pressure p_3 built up by the returning shock wave is usually not very different from the pressure existing in the receiver when the wave arrives at the valve. At this moment, therefore, there would be complete equilibrium with static air of equal pressure in the whole system, if it were not for the continuous loss of air through the interrupting nozzles (and secondary leakages). These "air sinks" create at first local pressure troughs (see Fig. 5), which, however, quickly broaden until they begin to draw fresh air from the receiver; this flow of air then represents the steady state. But it is important to note that the steady flow of air only begins some time after the nozzles have opened.

The ideal way to transmit compressed air with as little loss as possible is a straight passage of constant cross section. This principle applied to the design of air blast breakers means that, where several interrupting chambers are to be employed, they

§ *Ibid.*, paragraph 79.

will be mounted in tandem on top of each other.

We assume that the nozzle throat area is small compared with the cross-sectional area of the supply system. This is necessary for two reasons: first, to provide a sufficient volume of compressed air in the neighbourhood of the interrupting nozzles during the crucial first moments after contact separation, when the reflected wave runs towards the receiver and no continuous supply of air is yet established, and secondly, to prevent the nozzles nearer to the receiver from choking the continuous air supply to the remoter ones after it is set up. In connection with these requirements the distinct possibility should be kept in mind that the arc may already be interrupted during the period when the nozzles feed on the temporarily static air in the chambers. The compliance of a given design with these requirements can be regarded as proved if the experimentally found interrupting capacities of the different chambers turn out to be equal.

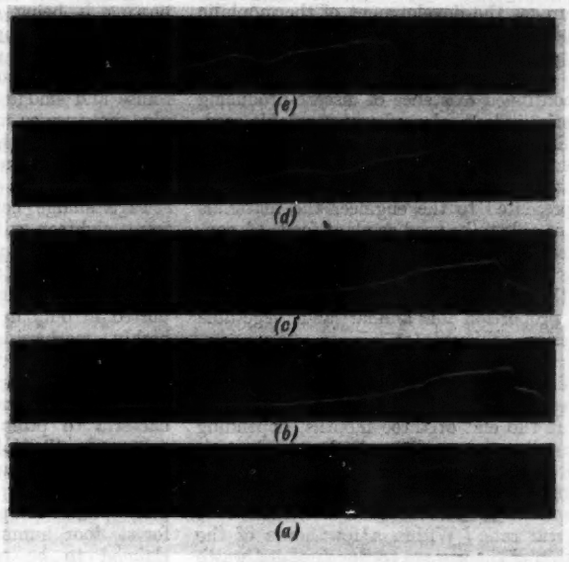


FIG. 9—PRESSURE OSCILLOGRAMS FOR 300 LB PER SQUARE INCH RECEIVER PRESSURE

In contrast to the blast valve, where inertia is objectionable, a certain amount

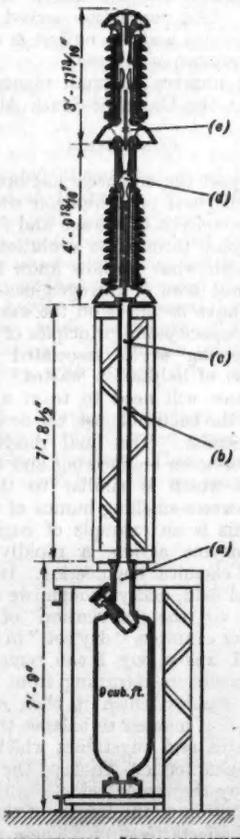


FIG. 8—EXPERIMENTAL ARRANGEMENT OF AIR BLAST CIRCUIT BREAKER

of the inertia of the interrupter is of great importance. Due to the inertia of the moving parts of the nozzles, the reflected waves have already left static high-pressure air in the interrupting chambers when they open. They are therefore all working under similar conditions; but even later, when the steady flow begins, there will be practically no difference between the nozzles because (the high-pressure air in the chambers, being above the critical nozzle pressure) it will be the nozzle throat that limits the air loss, and it can be kept small compared with the supply passages.

The waves running through the pipe system have a finite speed. The question therefore arises whether the nozzles will open at different times. It should be noted that due to the roughly linear increase of pressure when it just reaches the point to overcome the "Duo-Blast" nozzle springs, the nozzle opening will be proportional to at least the third power of the time*; even if a nozzle starts a tenth of its opening time later than another, the latter will only have opened a thousandth of its stroke. Thus, if the nozzle stroke is of the order of 1in the difference will only be 0·001in. In fact, the nozzles start to open with zero acceleration. Moreover, the pressures at which the nozzles open are themselves rather variable due to friction and spring setting, so that, even if the wave arrived at every nozzle at the same time, they would not necessarily open simultaneously. In fact, however, a large number of oscillograms have shown that, to all intents and purposes, nozzles physically mounted on top of each other do open at the same time.

In conclusion, we list those characteristics of the air blast process which follow from the theory[2] as verified by the reported experiments:—

(1) The pressure at the low-pressure side of the blast valve rises to 53 per cent of the receiver pressure immediately after opening.

(2) The peak pressure in this position is attained suddenly when the reflected shock wave returns from the interrupting chamber.

(3) In the blast feed pipe the outgoing pressure wave is still lower than the 53 per cent receiver pressure at the blast valve.

(4) The peak in the blast feed pipe is again reached suddenly on return of the pressure shock.

(5) Near the reflecting end of the air system there exists a region of interpenetration between the outgoing and the reflected simple compression waves; no intermediate pressure is observed there.

(6) Frictional pressure losses appear to be small; the pressure peaks reached depend mainly on the intrinsic mechanism of the building up of pressure at the position considered.

(7) The interrupting nozzles open before full pressure is built up on the downstream side of the blast valve or feed pipe.

(8) The peak pressures are practically the same at all test points, from the blast valve to the upper nozzle.

ACKNOWLEDGMENT

The author wishes to thank Mr. E. M. Dakin and Dr. H. F. Maass for very helpful discussions of the subject, Mr. F. Rushton, for his help and advice with respect to the experimental equipment used, and the management of Ferguson, Pailin, Ltd., for permission to publish the results.

BIBLIOGRAPHY

[1] Tsoirov, E. M., "Gas Dynamics of Air Blast Circuit Breakers," *Electrichestvo*, No. 12, pages 14–22, December, 1946.
[2] Riemann, B., "Abhandlungen d. Kngl Gesellsch. d. Wiss," Goettingen, 1860.
[3] Courant-Fredrich, *Supersonic Flow and Shock Waves*, Interscience Publishers.
[4] Durand, A., *Aerodynamic Theory*, Vol. II, Div. H., Articles by G. I. Taylor and J. W. Maccoll.
[5] Lindström, T., "Air Blast Circuit Breakers for 220kV and Higher Voltages for Swedish Networks," C.I.G.R.E. Report No. 105 (1948); "Topical Aspects of Air Blast Breakers," *Teknisk Tidskrift*, August 2, 1947, pages 561–70.
[6] McNeill, W. A., "High Voltage Outdoor Air Blast Breakers," *Engineering*, August 24, 1945.

* Experiments have since shown that a biquadratic parabola fits experimental results very closely.

The Engineer's Contribution to Soil Fertility

By HAL GUTTERIDGE

"And they took of the fruit of the land in their hands . . . and said, It *is* a good land which the Lord God doth give us."—*Deuteronomy* 1, 28.

A GOOD farmer has been defined as a man with a sense of humus!

Mixed farming on a small scale has always been the basis of a fertile soil whereby the nitrogen cycle could go round and round. In small-scale mixed farming the animals and crops complement each other, but the modern emphasis is on large area farming. In this case the nitrogen cycle breaks down for want of the nitrogen contained in humus, as no artificial manure can give the soil the waterholding properties of humus. Soil erosion and dust bowls have been the inevitable result of the neglect of the principles of the nitrogen cycle. The modern life of to-day collects mountains of town's refuse and seas of sewage in a year. For instance, in England and Wales in one year about 10 million tons of town's refuse are produced. We are taxed for the removal of this refuse and it is almost a dead loss to the community. It is in this field that there is scientific opportunity for reduction by further engineering achievements.

Man is like a plant, he has his roots in the ground; he has even been defined as a parasite on a cabbage. Any attempt of

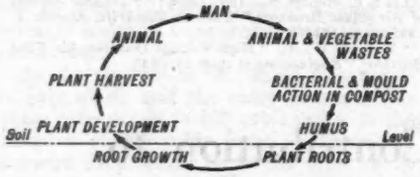
man to live outside the nitrogen cycle has always been a failure. The lifeless ruins of Babylon, half covered by the sands of the desert, are a grim memorial to those communities which, historically, tried to live outside the nitrogen cycle. The land of Lebanon, which produced the cedars of Biblical fame, is now on a much lower level of fertility because the contribution of humus material from those cedars has been lost. They were cut down by succeeding generations for their spiritual and secular needs. The silicious material of soil is only the scaffolding which enmeshes the nutritive humus from which the plant draws its nourishment; the humus, and the vegetation which it makes possible, enable the soil to resist the eroding effect of the wind and water. It takes twenty years to grow a tree and twenty minutes to cut it down; it takes 400 years to build up a fertile top soil and four seasons to rob it.

These aspects have been dealt with at some length because our biological friends quite rightly say that our engineering background is inorganic and we, as engineers, are only beginning to apply our service to biological ends. While we can claim to have been making valuable indirect contributions to biology in the part we play in refrigeration, brewing, domestic heating, water purification and sterilisation, they have substance for their views.

Conversion of Habitation Wastes to Manure

Recent experience has demonstrated that, by engineering methods, habitation wastes can be converted into an organic manure. At an early stage of this composting process the material sterilises itself by the heat of fermentation. A second sterilisation is effected, at a later stage of the process, by the growth in the material of moulds and fungi allied to penicillin. The secret of the metamorphosis lies in the encouragement of the aerobic organisms which produce odourless methane as the by-product of their action and the discouragement of the anaerobic organisms which produce hydrogen sulphide. In short, the environment created by the engineer brings about fermentation instead of putrefaction.

In the accompanying diagram of the nitrogen cycle it will be seen that the wheel



The Nitrogen Cycle

turns full circle. The engineer is presented with varying volumes of animal and vegetable wastes, with a predominance of sewage sludge by weight, the water content of which is about 90 per cent. This is a greater proportion than the town's refuse can balance. In future, the existing, usually overloaded, sewage works will only have to take the excess of sewage which cannot be absorbed by the town's refuse.

In the formation of the compost the idea to be aimed at is so to proportion the pulverised waste to the sewage sludge that the water content of the former—usually about 30 per cent—is brought up to 60 per cent by the water in the sewage sludge. With this balance between vegetable and animal wastes and water content, under proper conditions of aeration, the growth of such bacterial and moulds as are essential to the composting of humus will be maximal.

Thorough mixing of the compost at intervals during the early part of the process ensures wide distribution of the animal and vegetable components, the dispersion within the heap of the bacteria and the moulds, aeration and the uniform heating of the heap. The heat generated during bacterial action encourages the development of thermophilic (heat-liking) bacteria. These bacteria are not pathogenetic or disease-producing and they create an environment prejudicial to the continued existence of disease-producing bacteria, indeed, also of any vegetable seed. The final product, therefore, is acceptable on hygienic grounds.

In the form in which the habitation wastes are presented to the engineer the materials are not able to be used as plant food. A conversion by bacterial enzymes is essential. It is the responsibility of the engineer to ensure that the right conditions of aeration, moisture and proportion of animal and vegetable wastes are achieved.

Bacterial action reaches a maximum during the first three weeks in the compost bed. Thereafter the rate of activity slows down and at the end of three months, depending upon climatic conditions, the product is stable.

Immediately the refuse has been shredded it becomes inoffensive and unattractive to flies and rats. Within a few hours of the addition of the sewage to the shredded waste even the sewage becomes inoffensive. This is because the bacteria which are encouraged to grow in the compost bed are of the fermentative type instead of putrefactive.

Utilisation by Plant Root

When the humus is introduced into the soil by top dressing, followed by ploughing or harrowing, the waterholding capacity of the soil and its resistance to wind erosion are increased. The moulds and fungi in the compost provide a valuable nutritive intermediary between the soil and the delicate root hairs through which the plant draws its nourishment.

Plant Growth

When the plant draws nourishment made available to it from humus, the subtle alchemy of photo-synthesis in the leaves of the plant combines this nourishment with the sun's energy to promote growth of flowers and seeds. There is also evidence to indicate that under these conditions of growth the plant is more resistant to disease.

The vegetable harvest is made use of either directly by man or to him through the intermediary of an animal for his sustenance. It is interesting to recall that the most efficient converter of vegetable protein to animal protein is the cow, in her milk production.

In man's utilisation of the available animal and vegetable products, and in other aspects of modern living, man discards that portion unavailable to his economy and this brings us back to our starting point again of the utilisation of habitation wastes.

Existing Composting Plants

Engineering biology applied to the conversion of habitation wastes to a material of economic value as an organic fertiliser is known to be in operation in the following countries:—

Great Britain.—In Southwark, London, the separation of the salvable materials is being done locally, together with the immediate pulverisation of the remainder to render it inoffensive as well as unattractive to flies. Its transport to the composting plant or elsewhere is being arranged. The quantity of crude refuse handled is 20,000 tons per annum. At the Northern Outfall works of the London County Council composting of pulverised refuse from Southwark is being done with sewage screenings. The output of compost is 4000 tons per annum. At Leatherhead, in Surrey, composting is being done at a sewage works outside the town by pulverisation and lagooning in beds 30ft square by 3ft deep, with walls of refuse to contain the mixture of refuse and sludge without draining the surplus moisture or sub-aeration. The quantity of crude refuse handled is 1000 tons per annum. At Dumfries, a composting plant is located at one central sewage works with sewage sludge collected by tanker trucks from eighteen villages from distances up to 11 miles. The population served amounts to 44,000 persons.

Holland.—Crude town's refuse is transported in bulk in closed railway wagons to highly mechanised centralised composting plants in areas in the country where manure is required. The refuse is automatically discharged and sprayed with water containing bacteria to promote fermentation. There are composting plants with outputs up to 120,000 tons per annum.

Australia.—In Queensland there is a pilot plant composting pan sewage with forest floor humus. The fertility value is claimed to be treble that of unfortified humus.

New Zealand.—At Dannevirke materials composting takes place in beds 30ft by 12ft by 5ft high with sod walls. The materials are built up in layers, dusted with carbonate of lime and superimposed with a layer of partly matured compost and a thin layer of sludge. The population served amounts to 5000 persons and the output is 500 cubic yards per annum of compost.

A large number of small plants operate throughout the Union of South Africa.

Conclusion

In the past the emphasis has been on the æsthetic disposal of habitation wastes, but the whole concept of sewage and refuse disposal is going through an evolution more in keeping with what we now know to be the fundamental laws of nitrogen conservation. This will have its effect on the number, disposition, capacity and principles of design of all engineering works associated with the destination of habitation wastes. In future the engineer will need to team up in this field with the bacteriologist, the ecologist and the biochemist. The final result of this wedding between engineering and biology is a product which is similar to the brown crumbly sweeet-smelling humus of the forest floor. This is an example of engineer-controlled enzyme action, a rapidly growing branch of chemical engineering. In the constructional field, oddly enough, we apply our thoughts to the prevention of enzyme action; for example, "dry rot" in timber.

When I was a boy I can remember the market gardeners returning from the town (and the stables which it then contained) with a load of manure to balance the ingoing load of fruit and vegetables which the soil had brought forth. To-day, the horse is replaced by the motor vehicle, which makes no contribution to the humus of the soil and adversely affects fertility. These new techniques combine the wisdom of the East and scientific methods of the West to the end that we shall continue to live on a soil of restored and continued fertility.

Recent Isle of Man Steamers

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

IN common with all cross-channel services, those to and from the Isle of Man suffered acutely during the war, and many well-known and popular vessels fell victims to enemy action, thus necessitating their replacement. The Isle of Man Steam Packet Company has recently completed its post-war building and has put into service five new turbine steamers. The line in question is an old-established one, being upwards of 120 years of age, and for many years it had one of the finest fleets of paddle steamers in the kingdom, a typical example of which was "Queen Victoria" launched in 1887 and coming from the yard of the Fairfield Shipbuilding and Engineering Company, Ltd. She had the following dimensions: length, 330·5ft; breadth, 39·1ft; depth, 15·2ft; tonnage, 1657 gross. She was driven by compound diagonal engines with cylinders of diameters of 61in and 112in, with a stroke of 78in. Her boiler pressure was 100 lb per square inch and she developed 6500 i.h.p. With her paddle wheels revolving at 25 per minute she attained a speed on trial of 21 knots. A long line of paddle steamers culminated in "Empress Queen," built in 1897, the largest and fastest paddle steamer of her class, with a speed of nearly 22 knots, and having accommodation for 2000 passengers. Unfortunately, she was wrecked in a fog off Bembridge, Isle of Wight, in 1916, while carrying 1300 soldiers, and in spite of efforts to salve her she became a total loss.

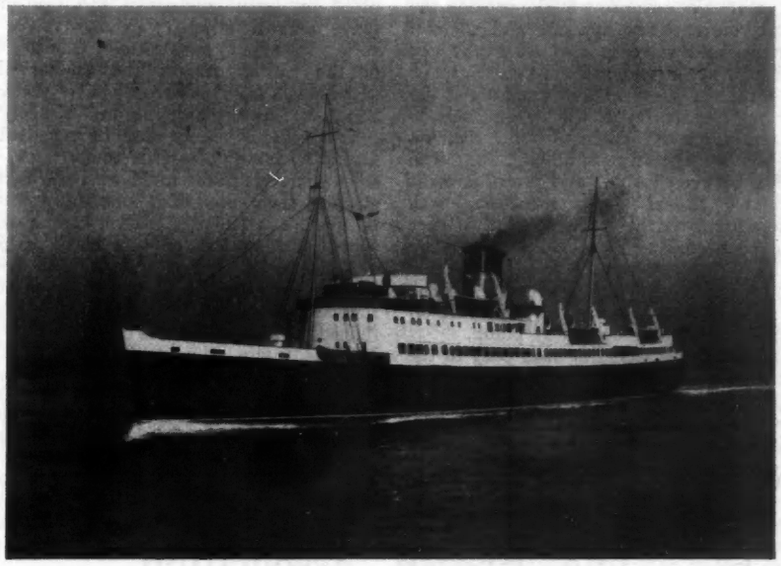
Paddle steamers remained in operation until 1929, "Mona's Queen" having the distinction of being the last of this class of vessel to be used on cross-channel work. From 1905 the turbine began to assert itself, and "Viking" appeared, a large ship 350·4ft long by 42ft broad, and with a tonnage of 1951 gross. Her trial speed was 23 knots, and she soon became popular and is still running, though her speed nowadays is reckoned at 19 knots. So satisfied were her owners with her performance that in 1908 "Ben-my-Chree" appeared, the largest and fastest cross-channel steamer of her day, for she was credited with a speed of 26 knots, which has hardly been surpassed down to the present day, while her length of 375ft was also exceptional. Both these steamers had triple screws with direct drive from the turbines.

In 1913 a further departure was made when "King Orry," the first geared turbine steamer, joined the fleet. There was nothing spectacular about her; she was smaller than her turbine sisters and with the lower speed of 21½ knots. But this class of vessel had come to stay, and larger and faster tonnage was built between the wars, including "Ben-my-Chree," the fourth of the name (1927), "Lady of Mann" (1930), and "Mona's Queen" (1934), their trial speeds being 23, 23½ and 22 knots respectively, and their tonnages 2586, 3104 and 2756 gross. The evacuation of Dunkirk led to the loss of "King Orry," "Mona's Queen" and "Fenella," which last-named, and "Tynwald," also a war loss, were modern turbine steamers, but smaller than their big sisters, built only two years before war broke out.

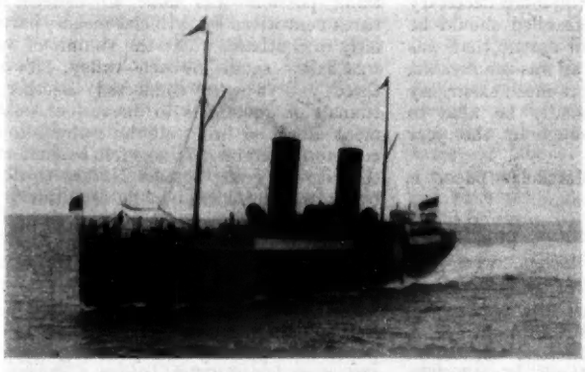
Apart from the steamers just mentioned, no two had been alike, but the five steamers built as replacements are genuine sisters, alike in all main particulars, and in outward appearance are almost indistinguishable. The first to be put into service was "King Orry," closely followed by "Mona's Queen" both in 1946; "Tynwald" in 1947, "Snaefell" in the following year, while 1951 saw the completion of "Mona's Isle." The present fleet consists of nine turbine steamers, so that the proportion of new vessels is high.

The dimensions of the "Mona's Isle" are:—Length overall, 344ft; between perpendiculars, 325ft; breadth, 47ft; depth moulded to shelter deck, 26ft; tonnage, 2490 gross. Each ship is capable of carrying 2300 passengers, for whom very comfortable accommodation is provided on four out of the five decks. On the promenade deck there is a spacious first-class lounge, smoke room and bar, and private cabins, while towards the stern is a buffet. On the shelter deck will be found a comfortable first-class ladies' lounge and buffet forward, while aft is similar accommodation for third-class passengers as well as rooms for baggage. In the bows of the main deck there is a well-equipped dining saloon, seating eighty first-class passengers, and aft are a third-class lounge, buffet and smoking room, while between the classes is accommodation for the ship's engineers. On the lower deck there are sleeping saloons for both classes of passenger, the first-class forward and third-class aft, and also a third-class restaurant, while in the stern is a mess room for the crew, and amidships the engine-room and boiler-room are located. Such is the general lay-out of the vessel. There are also eight private cabins, each with four sofa berths, wash basin, &c., and there are several bars about the ship.

The vessel is propelled by two sets of Parsons turbines driving the twin screws through single-reduction gearing. Each set consists of one impulse reaction type h.p. turbine and one all reaction type l.p. turbine,



ISLE OF MAN STEAMER "MONA'S ISLE"



PADDLE STEAMER "QUEEN VICTORIA"

ISLE OF MAN STEAMER "MONA'S QUEEN"

while incorporated in each casing are the astern turbines, which give about 70 per cent of the power of the ahead turbines. The propeller speed is 275 r.p.m. Three Babcock and Wilcox marine water-tube boilers, working at a pressure of 250 lb per square inch, provide the steam for the turbines, and they are operated on the closed stokehold system, the forced draught being supplied by two electric fans, and oil fuel is used. Two pressure units, each having a vertical steam driven pump, heater, &c., supply the necessary oil to the boilers; each set can furnish sufficient fuel for full power. Apart from the emergency bilge pump and the fresh water pump, which are electrically driven, the auxiliary plant is steam driven. Two turbo-generators, direct current, compound-wound, each of 150kW output at 220V, provide the electric current for lighting and general purposes, and there is also an emergency generator. Two condensers are on the outer side of each of the turbine sets and are of the Weir regenerative type, the cooling surface of each giving a vacuum of 29in with sea water at a temperature of 55 deg. Fah. The gearing between turbine and propeller shaft is double helical single reduction, with Parsons improved involute teeth, the turbines being connected to nickel steel pinions by flexible steel couplings. Forced lubrication supplies the turbine and gearcase bearings, the pressure being provided by two direct-acting pumps and one standby pump.

Particular attention has been paid to the safety of passengers, and there are six lifeboats, each 28ft long, all fitted with propelling gear and carried on mechanical davits, the boats being hoisted and lowered by electric winch. Fire alarm bells and sprinkler pipes are installed in all the passengers' and crew accommodation.

There is a bow rudder to facilitate leaving or entering harbour stern first or for manœuvring in narrow waters, this being controlled by telemotor from the navigating bridge.

As has already been mentioned, all five vessels are generally alike, but the latest "Mona's Isle" has a different gland steam arrangement. The leak off from the glands passes to a drain collector and then to a gland vapour condenser (sea water cooled), from which it passes through a filter to the feed tank. The Worthington emergency bilge pump is situated in the tunnel instead of the boiler-room, as in the other post-war ships. Gauge glasses are fitted on main condensers and feed filter tanks, and the auxiliary exhaust valves are spring loaded, automatic. Unlike that of the earlier vessels the shelter deck of "Mona's Isle" is covered in by Beclawat windows, this also applying to "Snaefell."

While these vessels may be regarded as second to none as regards comfort and the smooth running associated with the turbine steamer, their speed of 21 knots may seem to be low for a line which once specialised in speed, but owners of this class of craft evidently are of opinion that the much greater horsepower required for a relatively small increase in speed is not justified, and, indeed, on the mail boats from Holyhead to Dun Laoghaire, which once advertised their 24 knots, they are now content with 21 knots.

The author's thanks are due to Elsam, Mann and Cooper, Ltd., Dale Street, Liverpool, for the photograph of "Mona's Isle," which illustrates this article.

The British Association

No. I

AS recorded on the "Seven-Day Journal" page of our last issue, this year's annual assembly of the British Association for the Advancement of Science began, in Edinburgh, on Wednesday evening, August 8th. At a meeting in the McEwan Hall, H.R.H. The Duke of Edinburgh, K.G., F.R.S., delivered his presidential address entitled "The British Contribution to Science and Technology in the Past 100 Years." An abstract of the address appeared on page 176 of last week's issue. The meetings of the twelve sections of the Association continued until Wednesday last, August 15th.

Section G, Engineering

The meetings of Section G, Engineering, began on Thursday, August 9th, under the presidency of Sir Claude Gibb, F.R.S. In the morning, there were two sessions, running concurrently, at one of which two papers—"The Use of High-Ash Coals in the Electricity Supply Industry," by Dr. A. Alan Taylor, and "The Design of Large Boiler Plant for Using High-Ash Coal," by Mr. W. G. Marskell—were discussed. In the course of his paper, Dr. Taylor stated that nearly one-quarter of the increased coal requirements of power stations in Great Britain since 1939 had been made up of coals with dry ash contents higher than 22·5 per cent. Prior to the war such coals were scarcely consumed, and a big problem had been to use them satisfactorily on existing boiler plant designed for better fuel. It had been accomplished largely by attention to methods of cleaning boilers both "on" and "off" load, modifications of plant, changes in the methods of operating plant, and by distributing the poorer coals to the plants where they could most readily be used. The present shortage of boiler and power plant in the electricity supply industry emphasise, among other things, Dr. Taylor suggested, the importance of improved availability of plant and the necessity for that plant to be able to give its full output. Even in other circumstances, improved availability would be a national asset for it meant better use of the capital expended and better use of the manpower employed in manufacturing, operating and maintaining the plant. The electricity grid had enabled big savings to be made in the costs of power generation by reducing the amount of spare plant needed for emergency and also by the economic loading of power stations. Both those factors made it all the more necessary that such plant as was installed should be able to operate to the full extent that was required, and that, so far as was practicable, the power stations which produced electricity most cheaply should broadly be able to operate continuously throughout the year at full load.

An abstract of Mr. Marskell's paper is given on page 218 of this issue.

Civil Engineering Trends in Hydro-Electric Schemes

At the other session of Section G on Thursday morning, August 9th, two papers were taken, the first, by Mr. T. A. L. Paton, dealing with "Hydro-Electric Schemes: Modern Trends in Civil Engineering." The paper directed attention to the changes which have been made in civil engineering design and construction for modern hydro-electric developments, covering the design of dams, control of floods, and methods of drilling and lining tunnels. Other points mentioned were the new constructional methods and materials which had been necessary to overcome shortage of labour and materials, and the future of hydro-electric power in the light of the commercial development of atomic energy.

Mr. Paton said, in the course of his paper, that according to recent estimates, only 4 per cent of the estimated potential water power of the world at mean flow had been developed, excluding the power of the tides, but advance in the transmission of power over long distances, the linking up of generating stations by means of a grid, the diminishing resources of coal and oil fuel, the lower rate of interest on capital, and modern development in civil engineering had given considerable impetus in recent years to the development of hydro-electric power. As an example, the schemes in hand, or being surveyed, in the United Kingdom, principally Scotland, would increase the power available from hydro-electric schemes in Great Britain from 2 per cent, as at present, to 10 per cent of the present total electricity demand of the country.

Sir Edward Appleton, opening the discussion, commented on the author's references to sources of energy, and said that if the power of the tides were used to produce energy, it would mean tapping the energy of rotation of the earth. If too much were done to the tides, it seemed to him that it might lead to a slowing-up of the rotation of the earth!

Mr. Paton replied that there were practically no tidal action schemes, so that the earth could still go on for a long time!

Mr. R. W. Weekes asked whether the variation in run-off from catchment areas between −10 per cent and +15 per cent for successive thirty-year periods could be in any way traced to the action of man in changing catchment areas, by the building of towns increasing the rate of run-off and increasing the impermeability of the soil, or whether there was an actual change of rainfall in a given catchment area.

Mr. Paton agreed that changes resulting from building upon and developing land had to be borne in mind, but, in the case of the River Thames, studies which had been made did not show that the development of towns and so forth along its course was likely to have caused the variations.

Mr. J. P. Dunlop asked whether it was necessary to take any civil engineering action to increase or reduce the catchment areas for dams, in the same way as was done for drinking water purposes in certain more arid parts of the world.

Mr. Paton replied that certainly everything possible was done to increase the catchment areas by artificial means, particularly in Scotland, where the volume of water was fairly small in each valley. Two or three valleys were connected together by tunnels or aqueducts to increase the catchment area and bring all the water into one common reservoir. It was felt in some cases that it was going against Nature to do so, but it was considered to be essential to get as much water to control and to feed into the turbines as possible.

Mr. A. Feiner asked for more information on the lift or elevator type of fish pass, which had been very successfully used at the Leixlip dam in Ireland. It was stated in the paper that possibly this pass might replace the more lengthy fish ladder. The author had also stated that the technical advantage

of underground power stations was the reduction of friction, but was there not the almost equivalent difficulty that, although there might not be a surge chamber on the upstream side, there might have to be one on the downstream side?

Mr. Paton replied that from an engineering point of view there was no doubt whatever that the fish lift which had been installed at Leixlip would be perfectly adequate, but he could not give an answer from the point of view of the fish! The lift was a very simple device; it was a kind of tunnel going down the back slope of the dam and having a gate at the top and at the bottom, both of which worked automatically. A certain amount of water was always flowing through because the salmon liked to work their way against the stream. When the gate at the bottom was opened, the salmon swam into the little chamber; the bottom gate was closed after about eight minutes, and the top gate opened, and the tunnel gradually filled with water; the water carried the salmon up the tunnel and they swam out at the top. Nothing could be simpler from an engineering point of view; it was for the fishery experts to decide whether it would be satisfactory to the fish! While he had no information on the number of fish that went up, the chamber was about 8ft square and 5ft or 6ft deep, and could take twenty or thirty fish if need be.

With regard to underground power stations, while it was true that if there was a very long tail-race it might be necessary to have a surge chamber to damp down the rate of discharge from the tail-race when a machine was shut down suddenly, even so the saving in cost of the high-pressure pipes forming the penstock was very considerable when it was possible simply to drill a hole through rock, line it with concrete and let it be. There was reliance on the strength and the depth of the rock to resist all the forces of uplift and pressure, and there was a very simple arrangement, a separate pipe running straight through to each machine. But, of course, there were "snags." An effort had to be made to keep the power station dry. There had to be a false wall on the inside to allow any percolating water to trickle down it, and the power station had to be conditioned. Possibly the worst trouble was to design a plant in such a way that replacements and repairs could be carried out. It had been proved on a number of schemes that the saving in cost was something like 30 per cent. Moreover, in countries where this method had been considerably adopted the protection from avalanches and from ice was a very real advantage. That was an important matter in the high-up schemes in Sweden and Norway.

Professor W. F. Cassie, commenting on types of construction in which there was little need for impervious core, asked to what extent the figure of permeability of the dam would be affected if such core were to be omitted. Surely, he said, there must be some materials which would be pervious whatever was done to them. Mr. Paton said that he could not give an answer off-hand. He had not meant to imply that one did completely without any impervious core. The method was rather a selection of a sand-clay-earth mix which, when fairly compacted and wedded, would act definitely in the same way as an impervious clay.

Mr. P. L. Capper said that the designer of an earthen dam had to be prepared to accept a certain amount of seepage loss and, like other problems in engineering, it might be a case of striking a balance between the losses due to that cause and the extra cost of making a more impermeable dam, provided, of course, that the dam was perfectly stable and that the seepage was not likely to cause any trouble from erosion. He had been interested in the slides shown of dams and power stations which certainly were not blots on the landscape, but were, indeed, very pleasing structures. He recalled visiting the old Grampian scheme some years before the war and seeing a very fine-looking power station which was utterly spoiled by a mass of transformers and electrical stuff in the open alongside it. He had thought at that time how unfavourably the work of the electrical engineer had contrasted with that of the civil engineer. He hoped that in the more modern schemes something was being done to remedy that situation.

Mr. D. H. McPherson agreed that the power stations which the author had illustrated looked very fine, as did the dams when they were full; but he had seen pictures of them when they were half empty, and then one saw a vast expanse in which there was no vegetation at all, and they were undoubtedly a blot on the landscape. He felt that there was in this a challenge to the civil engineer and possibly to the botanists to overcome that particular feature of hydro-electric schemes.

Dr. J. Cameron Smail, referring to the author's description of the bucket by which erosion below the dam was reduced or prevented, asked whether there was any experience of the deterioration of the dam due to the scouring caused by the terrific rush of water. At Winnipeg power station, which was 90 miles from Winnipeg, he had seen a large dam being resurfaced on the back as a result of deterioration, and it had seemed to him that there might be some very considerable restoration problems arising with some of these dams. Of course, a great deal depended on the workmanship, and the technique of concrete construction had been greatly advanced.

Water Turbines for Hydro-Electric Projects

The second paper at the session was by Mr. R. W. Weekes, M.I.C.E., and Mr. A. Feiner, A.M.I.E.E., on "Water Turbines for Hydro-Electric Projects." It described the kinds of water turbines in common use and their characteristics, and went on to discuss the basic factors determining the class of turbine to be adopted for any particular installation. The authors also dealt with the control of and equipment ancillary to the turbine, and the lay-out of hydro-electric plant from the standpoint of turbine design.

Mr. T. A. L. Paton asked whether the authors had considered the economics of hydro-electric plant versus thermal plant under present-day conditions, and whether they had any figures about the economic cost for a hydro-electric scheme as compared with a thermal scheme.

Mr. Feiner replied that published figures, which he believed were taken from a paper by Mr. Paton himself, showed that the cost worked out at something between £85 and £100 per kilowatt for a hydro-electric scheme, and for a thermal power station—he was not sure whether the conditions were the same—at about £75 per kilowatt. But those figures referred to capital cost and did not take into account amortisation, which could be extended over a much longer period with a hydro-electric scheme and works which, he thought it could be truthfully said, would last much longer than a thermal station.

In reply to a question about the servo-motor and the floating lever mechanism of control, Mr. Feiner said that the basic elements of the governor were the usual basic elements of any governor with a floating lever arrangement. The major difference between the water turbine governor and the steam turbine governor was the size of the servo-equipment which actually operated the gates. The forces involved were considerable as compared with a steam set, but basically the governor was not different. It was possible that, as a result of experimenting with the equipment, the water turbine governor might be in advance of the steam turbine governor, but fundamentally the problem was the same, apart from the greater forces which had to be dealt with.

Mr. L. H. Fuller felt that too much emphasis should not be placed upon the capital cost of the water station as compared with the thermal station. At the present time, he said, it was a duty to make use of one natural resource when there were difficulties with regard to another natural resource, despite the extra cost involved.

Mr. Weekes explained that the machinery was a very small part of the capital cost of a hydro-electric scheme. The cement production, steel production, &c., that went into the civil engineering side of the scheme necessitated the drawing of a true balance between thermal and hydro-electric, because it was found in practice to-day that, while everything would appear to favour the hydro-electric scheme, the actual cost of civil engineering work had gone up so vastly in recent years that the advantages in favour of the hydro-electric scheme on an £ s. d. basis were not as great as one might anticipate. Against that, of course, it could be said that with a hydro-electric scheme there would not be used an exhausting supply of coal, and therefore the expenditure of money and labour on the development of hydro-electric schemes was a very fine investment for the future.

Mr. Feiner, in reply to a question as to whether cavitation problems had been entirely overcome, said that unfortunately they had not been, although with the greater research into cavitation, things were better. As far as the turbine people were concerned, the problem was really a competitive one. Everyone tried to use as high an operating speed as possible, but eventually there came a stop, and it was not possible to go any further. Cavitation problems had by no means been overcome and were still very real problems.

In reply to a member who asked what were the runaway speeds of the various turbines and whether there was any possibility of reducing them in order to ease the problem of the generator designer, Mr. Feiner said that the approximate runaway speeds were, for the impulse turbine 80 per cent above normal speed, for the low-speed Francis turbine 60 per cent, for the high-speed Francis turbine 125 or 130 per cent overspeed, and for the Kaplan anything up to 200 per cent overspeed. Attempts had been made to limit runaway speed and there was one patented design with a Kaplan turbine; but most people did not rely upon these measures and the generator was designed as if the runaway speed could possibly be attained. Thus, while attempts of this sort had been made, the problem had rather disappeared because of conservativeness on the part of the purchaser and also, perhaps, on the part of the designer. Runaway speed was simply considered as a necessary evil.

Mr. Weekes, in reply to a question whether at a power station in the U.S.A. having twelve Kaplan turbines it would not have been more economic to have had eight turbines with fixed blades, since the majority would always have to run with a full load, said that the adoption of Kaplan turbines was a matter of economics, with civil engi-

neering playing probably the most important part. With the daily fluctuation throughout the year of the rate of flow available, there could be no doubt that one could get the best available output from a group of machines with Kaplan turbines. On the question of installing all Kaplans instead of some Kaplans and some fixed blade, he would say that the machinery cost was small in relation to the civil engineering cost, and that the operators preferred to have 100 per cent flexibility rather than a number of units which they had to run at a fixed head as well as a fixed output.

Mr. Paton felt that, in conclusion, he ought to say a word in defence of civil engineering in relation to cost. The cost of civil engineering had not increased in any greater proportion than the cost of the plant or of the coal. He believed that the North of Scotland Hydro-Electric Board had more or less to justify its hydro-electric schemes as producing power at the cost of the cheapest thermal station in the United Kingdom. That was a pretty good recommendation for the development of hydro-electric power in Scotland.

Section G, Presidential Address

On Friday morning, August 10th, Sir Claude Gibb, C.B.E., F.R.S., gave his presidential address to Section G, entitled "Two Thousand Years of Engineering." He ended his review with the following predictions about the future :—

An address of this nature would not be complete without some prediction of the possible outcome of developments which, at the time of writing, are in their infancy.

Transport will always be a major item in civilised communities and there seems little doubt that the tendency in the future will be towards large-scale railway electrification in those countries where population and traffic density conditions permit this being carried out economically. This tendency may well be hastened by the application of nuclear energy, on a large scale, to the production of electrical energy.

The production of electrical energy from fissile material is, even in the light of our limited experience to-day, a practical possibility. With the prevailing costs of coal and petroleum and the present-day costs of uranium or other fissile materials, it is doubtful whether electricity could be produced, at the moment, more economically by the last-mentioned process than by other well-established methods; yet it requires but a small improvement in the method of using the heat generated by fission to enable atomic energy to compete with present-day practice. To justify the high initial cost of an atomic energy plant the production of electrical energy by fission must be carried out on a large scale, and so electrification of railways and other large-scale usage of electricity will automatically result.

For a long time now I have advocated the rational usage of our greatest national asset—coal. It is unlikely that in the future our available supplies of coal will increase; on the contrary, they are likely to become less year by year. Economics will therefore force us to use coal more economically and I foresee high-pressure gas mains supplying heat to home or industry, the complete abolition of the open coal fire, the increased use of slow combustion heating in homes using coke or other residual fuels, gas turbines living up to their names and using gas, and the use of coke, gas or tar, and, of course, high-ash coal residues for generating electricity in central power stations.

A great deal has already been done in the blending of coking and non-coking coals for gas production, and I expect work of this nature will be intensified so that the total output of coke will be increased and valuable by-products obtained.

Work is now being undertaken in this country in burning methane, which occurs in small proportions in the large volumes of air used in mine ventilation and it may be that in the future, by using a high degree of preheat, prior to combustion, the miner's greatest enemy—firedamp—will be used for the benefit of man.

Without any doubt, in my opinion, the jet or gas turbine cum jet will be used to the exclusion of all other means of propulsion for all types of aircraft. This type of prime mover meets the requirements so admirably that it is difficult to see how any other form of power unit can compete. On land, the gas turbine is more sorely pressed by its competitors, and I doubt if any prime mover other than the steam turbine, will be used for very large powers. I do think, however, that the gas turbine will, to a great extent, supplant the diesel engine. There is no difficulty in making gas turbine units of 100 h.p. which could easily be fitted to motor cars within the space now occupied by petrol or diesel engines. The major remaining problem requiring solution to enable the gas turbine to take its place in our everyday life is that of a compact, low cost and highly efficient regenerative heat exchanger. The consideration given to this problem during our present meetings is an indication of its importance and likely solution. Once a purely rotating prime mover has been found suitable for a given application, it always becomes possible to supplant an alternative reciprocating type, and there is little doubt but that within the next fifty years, the gas turbine driven motor car will be used to the exclusion of all others.

Man's standards of living and comfort have increased only as he has made mechanical power his aide and servant in increasing degree. Electricity provides the most convenient way of supplying that mechanical power, and if the nations of the world are listed in the order of electricity consumption per head of population, it will be found to coincide with the nations listed in the order of living standards. Incidentally, nations listed in the order of protein percentage in their daily diet give again the same sequence. Inevitably as nation after nation strives for improved standards of living and comfort, there must be a tremendous expansion in the generation and use of electricity. A consumption per head in Great Britain of five times our present electricity usage still would not produce demand saturation.

Large-scale use of electricity for pump-produced rain and for soil heating as a means of combating in some degree the vagaries of weather, and thus help solve our ever-growing food shortages, is certain to come.

Supersonic frequency electronically produced vibrations will become an everyday thing in our industrial, domestic and medical life. The thermionic valve will become an increasingly integral part of our life between 1951 and 2051.

When one considers the progress in engineering and the contribution to living standards in consequence which the century 1851–1951 has seen, he would be a brave—or a foolish—man who would put a limit to prophecies for the future.

Wing-Commander T. R. Cave-Browne-Cave, C.B.E., in proposing a vote of thanks to Sir Claude, said that he would suggest only one or two points which might help the section to express its gratitude and admiration for the address they had heard. He wondered whether it was not true to say that Sir Claude's great success in the great variety of engineering work which he directed was largely due to his ability to review a problem as a whole, as a picture in good perspective, against the correct background.

The Council had made a suggestion that presidents of sections should in this Festival Year review the progress of their subject over the period 1851–1951, but Sir Claude, who always gave full measure, had gone back and considered two thousand years of engineering—a thoroughly characteristic modification! But when one looked at the printed address, the benefit of that extension became clear: to have dispensed with the first part of the address and started at the paragraph headed "1851–1951" would have meant a great loss. The wisdom of going back and considering the whole subject in proper perspective was abundantly clear. It took a brave man to launch into prediction, because he knew perfectly well that what he wrote by way of prediction would be read some years later and would perhaps look very different then. But with characteristic courage Sir Claude had done this, and the benefit of his having done so was very great, for the prediction appeared to be a perfectly logical step from the review, and it had the advantage that it gave engineers a logical, constructive idea of what were the problems which it was really important to tackle. That would be of enormous help to engineers.

(*To be continued*)

A Trial Use of Transistors

Transistors will be put into trial operation in the Bell Telephone System (U.S.A.) early next year. These small amplifiers, invented several years ago at the Bell Telephone Laboratories, are said to have been improved to the extent that they are now as uniform in performance as electronic vacuum valves. Known as point contact transistors, they consist essentially of two hair-thin wires resting on a minute speck of germanium, which is a semi-conducting metallic element. There is no glass envelope, no vacuum and no heating element, to cause a warm-up delay. Transistors, which have been produced at the laboratories, are claimed to be able to withstand shock and vibration better than any known vacuum valve and are expected to have a service life considerably longer than that of valves in current use. They also can be designed for a great many specific functions, including applications which at present require vacuum valves. In addition, the transistor is expected to find future application in telephone apparatus where the use of valves is not practical. The Bell Telephone Laboratories also has developed an amplifier called a junction transistor. This transistor has no point contacts, which in the original transistor correspond to the terminals of a vacuum valve. In the form of a small bead about half the size of a pea, it consists of a small rod-shaped piece of germanium treated so that it embodies a thin, electrically positive layer sandwiched between the two electrically negative ends. Such junction transistors have been found to be more efficient, to consume less power and to be smaller in size than the original point contact transistors.

"Canada, 1951."—We have received a copy of "Canada, 1951," which is the official handbook of present conditions and recent progress in the Dominion. It has been prepared by the Dominion Bureau of Statistics and is published by the Department of Trade and Commerce, Ottawa. The book, which is admirably illustrated, not only reviews the social, educational and cultural affairs of Canada, but contains also much useful information about the finance, trade, industries, mineral and power resources, transport and communication, and labour situation throughout the Dominion.

Continuous Brass Strip Mill at Waterbury, Connecticut

No. II—(*Continued from page 182, August 10th*)

The Finishing Mill

THE finishing mill is of the same size and the same design as the run-down mill and operates also within a range of 0/400/1000ft per minute, handling the same coils as the run-down mill but in lighter gauges. The reeling unit was designed to handle strip in thicknesses down to 0·011in. The mill is provided with the same equipment and conveyor system as the run-down mill, except that it does not have the vacuum-cup crane and the roller table, since it is used for coils only.

Both mills have a common oil cellar, in which are situated the roll coolant systems, the strip lubrication system, the lubrication system for the gear drive units, the lubrication system for the mill bearings and the roll balance hydraulic system. There are two roll coolant circuits, arranged to facilitate the use of different solutions on the two mills. Either circuit is of sufficient capacity to supply both mills when they are operating on the same solution and the piping and valves are so arranged that either circuit can supply either mill stand. The various systems are provided with alarm signals, to indicate pressures dropping below a predetermined value.

The electrical equipment for these two mills was manufactured by the Westinghouse Electric Corporation. The main drive for each of the mills is essentially duplicate in character and only minor differences occur in the auxiliaries. The drive for each mill consists of a 1250 h.p., 600V, 0/400/1000 r.p.m., d.c. mill drive motor; a 5 h.p., 230V, 400/1000 r.p.m., d.c., wiper roll drive motor; a 75 h.p., 230V, 300/1200 r.p.m., d.c. blocker drive motor and a 50 h.p., 230V, 400/1200 r.p.m., d.c. motor for the upcoiler drive. The 1250 h.p. mill drive motor is supplied with power from a 1000kW, 600V, d.c. generator, thus forming an adjustable voltage drive system. The 5 h.p. wiper roll motor, the 75 h.p. blocker motor, and the 50 h.p. upcoiler motor are supplied with power from a separate 75kW, 230V, d.c. generator, forming another variable voltage system. The speeds of the latter motors are co-ordinated with the speed of the main drive by means of "Rototrol" regulating exciters. The blocker and the upcoiler constitute alternate methods of operation and are not run at one and the same time. The metal is coiled in the upcoiler until its thickness is such that it can be reeled, at which stage the upcoiler is disconnected and the blocker unit is put into operation. A "Rototrol" regulating exciter controls the tension on the blocker so that it is maintained essentially constant during normal running operation as well as during acceleration and deceleration periods. Special means for inertia compensation have been provided to maintain strip tension as constant as possible under conditions of mill acceleration and deceleration.

A special light gauge four-high Morgan finishing mill was installed to deal with the finish-rolling to thin gauges of narrow width stock. Its roll sizes are 6½in and 14½in by 12in; it has a speed range of 0/600ft per minute and is driven by a 250 h.p. General Electric motor. This mill is equipped with an X-ray gauge to measure the thickness of the strip at the delivery side.

Annealing Furnaces

There are four roller-hearth continuous annealing furnaces, all fired with propane gas. A break-down or "short-bar" "EFCO" annealing furnace is installed to handle bars ranging from 9ft 9in to 42ft 3in in length and to anneal at thicknesses varying from 0·40in to 1·75in. Standard bar widths are 16in, 24in and 29in, although other widths are handled occasionally. When dealing with 16in wide bars, three of these are handled across the width of the furnace; 24in or 29in wide bars are handled two in width across the hearth of the furnace. The maximum capacity of the short-bar annealing furnace is approximately 37,000 lb per hour, with a normal expected capacity of approximately 33,000 lb per hour. In order to reduce the overall length of the furnace to a minimum, it was decided to make use of a flame impingement preheating chamber. The furnace equipment is 117ft in length. This length, however, does not include the loading and unloading extensions, with the handling equipment for handling the bars on to the loading extension and the handling equipment for unloading the bars from the discharge extension. Each of the latter is approximately 45ft in length, including a 5ft charging extension, the flame impingement or preheat chamber, the conventional furnace chamber, the spray quench chamber and a 5ft discharge extension. The floor space requirements, if the above-mentioned preheat chamber had not been employed, would have been increased by approximately 53ft, making the length of the equipment between the loading and unloading mechanisms approximately 170ft instead of the present length of 117ft. The major portion of the heating is done in the preheat chamber, with the long, conventional heating chamber being used to equalise and to take care of the final heating of the bars to the desired annealing temperature. A spray chamber is provided for rapid cooling of the bars from the annealing temperature to facilitate their being handled as soon as they are delivered to the discharge table. Since the major portion of the production involved is copper-base alloys, containing zinc, which would cause discoloration, there was no justification for a full atmospheric control. Furthermore, this becomes unnecessary on account of the bars being conditioned at approximately 0·40in gauge. By means of auxiliary burners in the last two zones, it is possible to heat all zones of the furnace equipment to operating temperature at about the same rate of speed after a shut-down period. For use in the event of interruption of the electric service, the unit is provided with an internal combustion engine operating on propane gas, to take over the driving of the rolls, to protect the furnace equipment. The driving mechanism from the actual drive shaft to the various sets of rolls is further protected so that in case there should be a failure of the driving chains for a given group an alarm is sounded.

The remaining three roller hearth continuous annealing furnaces were designed and built by the Surface Combustion Corporation. They were designed for production capacities ranging from about 32,500 lb per hour of coiled sheet to 36,700 lb per hour of bar stock. One of these furnaces, referred to as the "long-bar" furnace, is an assembly composed of a heating chamber joined together with a specially constructed high-capacity preheater, a cooling chamber and a quenching tank. It is designed to take bars from 0·400in to 1·750in thick in lengths up to 65ft. The high-capacity preheat chamber is about 14ft long and contains air-cooled, power-driven Inconel conveyor rolls similar to those in the main heating section of 69ft length and the slow-cooling section of 5ft length. The stainless steel spray-quenching chamber is 12ft long and has water-cooled brass conveyor rolls. Altogether, this forms a furnace over 100ft in length with an added driven charge table and a receiving table. Each roller is chain driven from a counter-shaft drive running the entire length of the furnace.

The other two furnaces are of similar design but do not include the special preheat chamber. Within limits, they are duplicates, one unit can handle coiled sheet and bars, while the use of the other furnace is restricted to coils. Both non-leaded and leaded brasses can be processed in these furnaces. They are handled in the form of slab or bar stock 16in or 24in in width and weighing 2000 lb, or as coiled sheet stock measuring 23in to 30in in outside diameter and being of the same weight. The work travel pattern is two or three parallel rows of bars, two-high, or two parallel single rows of coils. While the furnace is designed for maximum production at temperatures up to 800 deg. Cent., and for uniform annealing conditions at temperatures as low as 250 deg. Cent., in actual production the bar stock is annealed at 750 deg. Cent. and the coiled sheet stock at 570 deg. Cent. The metal being annealed is conveyed through the heating chamber, then through a quenching section and, finally, is discharged on to delivery tables. The furnace speed ranges from 1·8ft to 7·8ft per minute and the pass line is approximately 3ft above floor level.

The continuous coil furnaces are both divided into two main work sections—the heating chamber and the cool and spray quenching portion. The 100ft heating chamber in both furnaces is further divided into five heat zones to obtain flexibility of heating cycles. This permits the changing of processing temperatures by merely leaving an empty zone between different charges and, thus, eliminating the necessity for resorting to the costly and time-consuming operation of clearing the entire furnace. The burners are low-pressure, automatically-proportioning, velocity units, burning propane gas. They are mounted in the side walls and are staggered to fire above and below the work. To give an even distribution of heated gases through the charge, especially during the annealing of sheet coils, thirteen recirculating fans are situated in the ceiling of the furnace chamber. Adjacent to the discharge end of the furnace there is a refractory-lined 6ft long slow-cooling chamber and a stainless steel 12ft long spray-quenching chamber. Because of the weight requirements encountered in continuous brass annealing, the power rollers used in the heating chamber and in the slow-cooling chamber are fabricated of extruded Inconel and are spaced at 10in centres. They have an outside diameter of 7in, a wall thickness of $\frac{7}{16}$in, and a rated capacity of 2000 lb per roll at 800 deg. Cent. Power for the rollers is obtained from a sprocket-and-chain arrangement on the outside of the furnace geared to a 3 h.p. conveyor drive motor through a double transmission. The quench tank rollers are made of brass and are water cooled. Both the continuous coil annealing furnaces measure about 116ft in length, including the cooling and spray-quenching chambers. As it is a generally accepted fact in the industry to-day that the properly controlled direct-flue products of combustion in a direct-fired furnace are suitable for the annealing of copper and many of the copper-base alloys, a prepared-atmosphere gas is not used in any of the coil furnaces.

Spray Pickling Lines

In co-operation with the engineering staff of the Scovill Manufacturing Company, the Metalwash Machinery Corporation designed and built the two spray-pickling machines, capable of handling strip up to 29in wide at speeds up to 600ft per minute. Each of the lines is more than 150ft long and consists of a coil pay-off reel, a set of feed rolls and a strip flattening unit, a series of processing tanks, air blast drying units and, finally, a coil take-up provision—an expanding-mandrel winding reel for light-gauge strip; and a combination three-roll bender and coiler for heavier stock. When passing through the processing units, the strip is subject to the following treatment cycle:—

(1) 10 per cent sulphuric acid power spray-pickle at 60 deg. Cent.

(2) Bichromate (10 per cent sulphuric acid plus 3 per cent bichromate) power spray-pickle at room temperature.

(3) Cold fresh water spray-rinse to sewer.

(4) 10 per cent sulphuric acid power spray-pickle at 60 deg. Cent.

(5) Recirculated cold water power spray-rinse combined with fresh water rinse.
(6) Recirculated soap power spray-rinse.
(7) Cold fresh water spray-rinse to sewer.
(8) Cold air blast.
(9) Hot air blast.

Apart from the fact that, compared with conventional immersion-pickling, spray-pickling facilitates considerably higher speeds with a relatively short line, the scrubbing action of the high-velocity sprays leads to a superior appearance and surface condition of the brass strip, thus eliminating the need for subsequent brushing. In the design of the two pickling machines particular attention was paid to the control of solution carry-over between individual tank sections.

Another unusual feature of the lines is the manner in which the coil is threaded through the machine. In the conventional strip pickler the "lead" end of one coil is generally attached to the tail end of the preceding coil by means of stitching. This operation makes it necessary to stop the machine before the tail end has entered it, which means that a portion of the strip is exposed to the action of the acid for a longer period of time than is necessary to clean it. For this reason that portion of the strip may be overpickled or etched. In order to eliminate this possibility the "leader bar" method of threading was developed. This "bar" is simply a stainless steel frame, the weight of which develops sufficient friction between the conveyor rolls of the machine and itself to carry it through the machine. When in operation the "leader bar" is placed on the rolls of the entry table. A spring-loaded clamp or jaw on the tail end of the "bar" is opened, the "lead" end of the coil is inserted, the clamp is closed on the strip, and the machine is started. As the "bar" emerges from the discharge end of the machine it passes between open pinch rolls and on to the discharge table. At this moment the pinch rolls close on the strip and the "leader bar" automatically releases its grip. The speed of the rolls on the discharge table is greater than that of the pinch rolls which now control the speed of the strip. This means that the "leader bar" runs away from the strip on to a section of the table which is rotated through 90 deg., using one edge of the section as an axis. This motion carries the "bar" out of the path of the strip and changes the plane of the "bar" from a horizontal position to a vertical position. At this point rollers which are built into the edge of the "bar" engage a rail which slopes back to the entry side of the machine and serves as a gravity conveyor to return the "bar" in time to service the next coil. In the meantime the section of table which disposed of the "bar" has returned to its original position before the end of the strip has reached that point on its way to the block or coiler. With this method the strip or sheet moves continuously through the machine, thus eliminating the possibility of overpickling or etching in patches.

Heavy-Duty Slitting Line

The heavy-duty slitting line is the first of three slitting lines of the continuous strip mill, all of which have been designed and built by the Waterbury Farrel Foundry and Machine Company. The heavy-duty line, which is illustrated in Fig. 7, is capable of handling ¾in thick metal, hard or annealed, in widths up to 30in. The first unit on the line is the coil box, which takes coils up to 33in in diameter and 2000 lb in weight. The machine is driven by a 5 h.p. geared motor and is fitted with anti-friction rollers for supporting the coil. These rollers are chain driven from the motor, through an overrunning clutch, to provide free-wheeling for the coil. The side plates are individually adjustable by hand wheels to suit the width of coil. and the side guides are adjustable and air-operated vertical rollers. The coil pin is pneumatically withdrawn for loading purposes. The coil box is equipped with wheels for supporting the unit on rails; this provides the necessary sliding movement for inserting the tail of the coil into the feed rolls of the the straightener, which is the next unit within the line. This movement is derived from an air cylinder situated below the floor line. The metal next passes to a five-roll straightener with feed rolls and is driven by a 40/50 h.p. motor. The unit is equipped with a pneumatic metal wiper, actuated by a four-way solenoid valve through a limit switch. The wiper remains up until the coil box has been rolled forward and the metal passed to the feed rolls. After straightening, the metal passes over a guide table on the outgoing side of the machine to the gang slitter.

The No. 6 heavy-duty gang slitter employed in this installation has a capacity for 30in wide metal and is able to make five cuts on ¾in brass at a speed of 150ft per minute. The slitter is driven by a 100/125 h.p. motor through a speed-reducing unit. The cutter spindles turn in roller bearings and are equipped with 16in diameter sleeve-mounted cutters. The tail stand of the machine is retractable electrically on to an extension of the bed, which is mounted on a pedestal supported on anti-friction bearings, so that the tail stand can be swung out of position manually by the operator for convenience in setting up the cutters and sleeves. A rotary scrap cutter mounted directly behind the slitter is capable of cutting 1½in wide scrap into 2in lengths, and is independently driven through vee belts by a 10/15 h.p. motor. Each of the two-piece rotor section has two cutter blades, 180 deg. apart, assembled so that only one piece of scrap is cut at a time. The upper feed roll is pivoted and spring-loaded and is driven by friction from the lower roll as the metal passes through. The next unit is an up-cut shear, used to square the tail ends of the strip and to cut the strips to length. The cutter blade has a ⅝in per foot shear, and the up-stroke of the slide is 3½in. Finally, the metal strips pass over a guide table leading to the feed rolls of a three-roll coiler. This machine is driven by a 40/50 h.p. motor within a speed range of 100ft to 300ft per minute, its coiler rolls being 6in in diameter and 34in long. The upper coiler roll and the upper feed roll are vertically adjustable by a hand wheel. The tailing device and the coil kick-off mechanism are actuated pneumatically from an air cylinder through a solenoid valve.

Medium-Duty Slitting Line

This slitting line may be used for either conventional slitting, in which the metal is fed through, or for "pull-through" slitting. It is designed to handle hard or annealed brass strip or sheet not over ¼in thick and 30in wide, in coils up to 2000 lb in weight. The pay-off stand has a speed range of 100ft to 1000ft per minute and is driven by a 5 h.p. motor equipped with an air cooler for high speeds. The motor speed is regulated to give a back tension to the metal as it is unwound from the drum. This drum is a four-piece hydraulically-operated expanding unit, 13½in in diameter when collapsed and 17in when expanded. There is an 8in lateral movement provided for lining up the coil with the straightener, by means of a motor-operated screw situated at the left-hand end of the machine. The pay-off is mounted on slides on a base which is retractable hydraulically to facilitate "sticking" (i.e., feeding to the straightener rolls) by means of a 4in diameter cylinder situated below the floor line. The straightener, which is second in the line, runs at 450ft per minute when handling ¼in metal and proportionately faster when dealing with thinner gauges. It is driven by a 20 h.p. motor and is equipped with adjustable air-operated roller entry side guides and an air-operated metal wiper. On leaving the straightener, the metal passes over a removable table to the up-cut shear. This machine, which trims the tails or cuts the strip as required, is similar to the shear employed in the ¾in slitting line, except that it is not back-geared. Between the shear and the gang slitter there is a retractable roll-feed unit, driven by a 3 h.p. geared motor through an over-running clutch. The rolls are 5in by 32in. The feed unit is provided with a 6in diameter, 1in stroke air cylinder for raising and lowering the upper roll and has adjustable air-operated side guides. The whole unit is mounted on rolls and is retractable laterally on rails by means of an air cylinder. A removable table spans the space between the feed unit and the slitter, which is the next machine in the line.

The slitter has a maximum slitting capacity of five cuts on ¼in metal at 450ft per minute, and is fitted with an over-running clutch. For conventional slitting this clutch is locked; for "pull through" slitting it is released. The upper spindle bearings are adjustable simultaneously by means of a handwheel. The tailstand is movable laterally by means of rack and pinion and a manually-operated ratchet spanner and it can readily be swung out of position for convenience in assembling the cutters and sleeves. A rotary scrap cutter, situated directly behind the slitter, has a capacity for cutting 1in wide scrap into 2½in

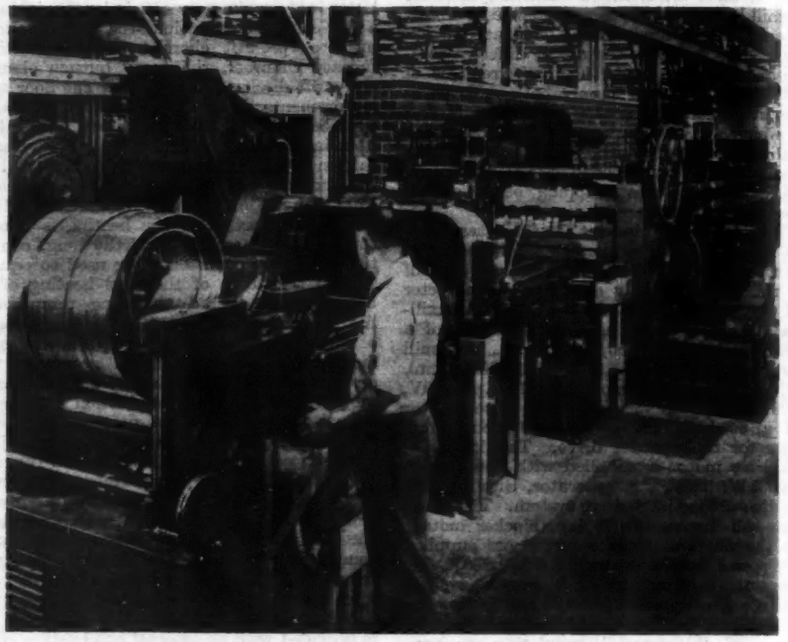


FIG. 7—HEAVY DUTY SLITTING LINE

lengths, at a slitting speed of 450ft per minute. The last two units within the line, a winder and a coiler, are both retractable so that if the strips are to be recoiled the winder is moved out of line. Otherwise the coiler is retracted and the metal is passed directly to the winder drum. The coiler is similar to that described in connection with the ¾in slitting line, except for its size. The winder, which is the unit alternative to the coiler, is capable of winding 0·090in thick metal at 1000ft per minute and is driven by a 60 h.p. motor. Its three-piece, 12in diameter drum has a capacity for 30in diameter coils up to 2000 lb in weight, and it can be increased to 16in diameter by means of fillers. It is manually expanded and collapsed, the coils being stripped from the drum hydraulically.

Light-Duty Slitting Line

This line is designed to slit hard or soft brass, 0·032in to 0·005in thick, 30in wide, in coils weighing up to 2000 lb. Like the medium-duty line, it comprises a pay-off stand, the slitting machine, a scrap conveyor and a winder; however, it is not equipped with a straightener, a shear and a coiler. The strip passing through this line has a base speed of 300ft per minute; whenever this is exceeded, due to the winding unit speeding up, the over-running clutch of the slitter becomes disengaged and the line commences to operate on the "pull-through" principle. It is of interest to note that both the pay-off stand and the winder of this line are driven by hydraulic motors, which obtain their power from two "Vickers" constant-displacement fluid pumps driven by a 50/60 h.p., 250/1200 r.p.m., 230V d.c. motor. The hydraulic winder motor provides constant strip tension throughout the 300ft to 1500ft per minute speed range of the line.

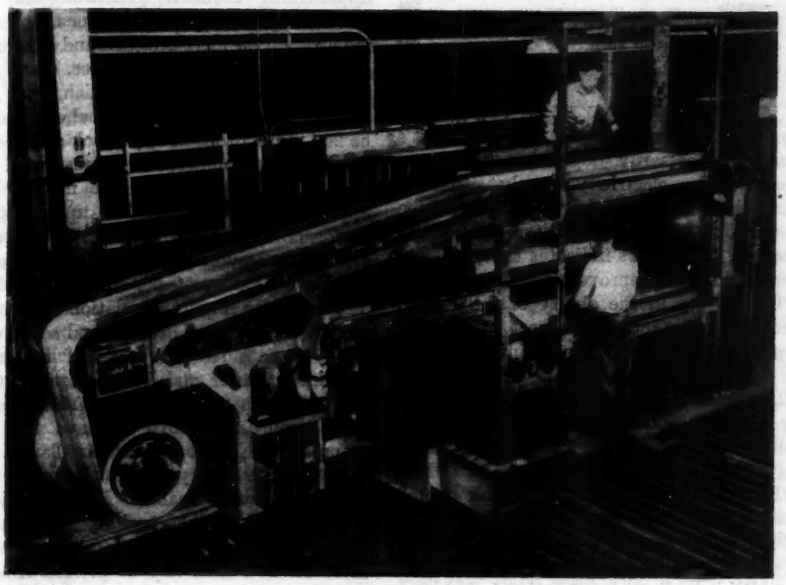


Fig. 8—Strip Inspection Machine

Mechanical Handling Equipment

The wide variation in specifications covering metals encountered in the non-ferrous industry does not permit the synchronising of the various rolling, annealing, shearing and slab milling operations. To overcome, as far as possible, this condition and in order to provide for more economical operation and production efficiency in the new continuous strip mill, a system of roller conveyors was installed connecting essentially all of the flat bar processing equipment. Furthermore, a need for the conservation of floor space and the desirability of reducing to a minimum the handling time by means of overhead cranes, led to the stacking of bars on this roller conveyor system. Bars are fed into and discharged from the equipment one at a time and it was this combination of both multiple and individual handling which necessitated provision for means of piling and unpiling the bars. Various factors, such as speed in handling different starting or rolled sizes of bars, the requirement for annealing several such different sizes of bars, and prevention of damage to metal surfaces influenced the decision to adopt vacuum handling for transfer of the flat bars in preference to other types of handling equipment.

Basically the vacuum handling equipment for this type of service consists of a load-carrying beam, supporting a series of rubber cups, attached to suitable supports arranged so that the load beam with its cups can be moved laterally a sufficient amount to permit removing one bar at a time from a delivery table and forming a stack adjacent thereto, or removing one bar at a time from a stack and depositing it on an entry table. The vacuum cups have individual hose connections to a pipe header connecting to a motor-driven exhauster, which creates the required vacuum for supporting a bar while being transferred. The lifting power of a given size of cup is dependent on the degree of vacuum or pressure pushing the bar against the cup. For the class of service involved the general practice is to use a design pressure of approximately 7 lb per square inch. This, for example, means that a vacuum cup having an area inside the rubber seal ring of 50 square inches would have a theoretical lifting capacity of 350 lb. Thus, at this air pressure a 2000 lb flat bar may be lifted readily when a line of vacuum cups are affixed simultaneously to such a bar. Two kinds of supports for the load-carrying beam are in general use at the mill: one composed of a travelling structural bridge with wheel bogies at the ends and supported on runway rails above the bars to be handled; the other one a series of stands and cantilevers, pivoted at the stands, to which the load-carrying beam is attached. In the former type the load beam may be arranged for longitudinal as well as lateral movements, which are effected by means of hydraulic cylinders. In the latter type the supporting stands are equipped with vertical cylinders for elevating the load bar and horizontal cylinders for swinging the arms about the stands after a bar has been picked up.

The following description relating to the manner of operation of the travelling bridge load-carrying beam of the depiling unit at the entry side of the short bar annealing furnace is presented as an indication of the manner in which the vacuum handling equipment is being employed. This particular unit has a maximum bridge travel of 7ft 5½in, a maximum cup lift of 18in and a carrier beam longitudinal traverse of 18in. The depiler frame has a span of approximately 47ft between supports. The equipment is designed to transfer flat bars of various widths from a single position on the storage roller conveyor adjacent to the furnace and place them at different locations on the furnace entry table. This condition at the furnace entry table precludes a completely automatic cycle of operation. The cycle of operations is started with a flat bar on the cups and with the cup-carrying beam raised to the "up" position above the pile of bars. The operator manipulates manual valves which control the stroke of the hydraulic cylinders provided to traverse the bridge and thereby position the bar at the proper location transversely over the furnace approach table. The carrying beam, with the bar attached, is then lowered to the desired height over the approach table by manual operation of valves controlling pneumatic cylinders and, if necessary, is also traversed longitudinally by a manually-controlled hydraulic cylinder. Once the bar is in the desired position over the furnace table the operator presses a push button, thus starting the automatic cycle, which performs these functions in the following order:—The vacuum is released, allowing the bar to drop, and the carrier beam is simultaneously raised to its top position. At this point contact is made with a limit switch, which energises a valve applying hydraulic pressure to the traverse cylinders, moving the bridge to a position over the stack of bars. Vacuum is now automatically restored and the cup-carrying beam is lowered to the stack, where the cups, having made contact with the bar, are automatically raised to the top position, thus completing the automatic portion of the cycle. The equipment is now ready for the operator to make the next transfer. An adequate system of interlocks and controls is provided to ensure the proper sequence of operation and to prevent, as far as possible, injury to personnel or damage to either the equipment or the metal being handled or transferred.

For the handling of strip material to be inspected finally a special strip inspection machine has been installed, which is illustrated in Fig. 8. It facilitates the simultaneous inspection at two respective levels of both sides of the strip and is capable of feeding the material past the inspectors at speeds ranging from 60ft to 240ft per minute. It can handle strip from 0·004in to 0·050in in thickness and from 12in to 30in in width, in coils weighing up to 2000 lb. The initial threading of strip through the machine is accomplished by means of two side-threading chains running along the frame of the machine.

Silica Bricks

During the past few years the Coal Carbonisation Plant Committee, which is responsible for the progressing of construction of coke ovens and carbonising plant, has experienced confusion between makers and users of refractories on the meaning of silica bricks, siliceous bricks, semi-siliceous bricks and firebricks. The Ministry of Supply—which had responsibilities in this field before the Ministry of Materials was formed—was asked to ascertain whether agreement could be obtained between the interested organisations. The Ministry has now reported to the Committee as follows:—

Silica Bricks.—Bricks containing at least 92 per cent silica.

Siliceous Bricks.—Bricks containing 85 to 92 per cent silica.

Semi-Siliceous Bricks.—Bricks containing 78 to 85 per cent silica.

Firebricks.—Bricks for which the silica content is below 78 per cent.

The British Ceramics Research Association and the Director of the National Federation of Clay Industries were consulted, and are in agreement with the classification. It should also be noted that this classification corresponds with the information in "Technical Data on Fuel."

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HARSH WINTER PROSPECTS

At the beginning of last month the Minister of Fuel and Power told the annual conference of the National Union of Mineworkers at Blackpool of his intention to set up a committee "to consider whether any further steps can be taken to promote the best uses of Britain's resources in fuel and power." Last Friday, as we note elsewhere in this issue, the names were announced of those who are to serve on that committee under the chairmanship of Viscount Ridley. The appointment of the committee appears to be the outcome of the initiative of a deputation from the Federation of British Industries and the Trades Union Congress, which waited upon the Chancellor of the Exchequer and the Minister of Fuel and Power last March to discuss measures "for the establishment of a national fuel policy for the efficient and economical use of all forms of fuel and power, particularly coal." We have therefore the paradoxical situation that, though one of the arguments used in support of the nationalisation of the coal, electricity and gas industries, and of road and rail transport, was that the great bodies so created could, more easily than private industry, work out co-ordinated activities amongst themselves, and under the general direction of the Government, the latter has had to call in independent individuals and representatives of private industry to study how best that co-ordination is to be achieved! We hope that the terms of reference will prove wide enough to permit discussion of such far-reaching proposals as those Sir Claude Gibb, happily a member of the committee, has propounded from time to time, and which have been reported and commented upon in our pages.

The work of the new committee will relate, we suppose, to long-term rather than short-term plans. Yet one of the purposes of the committee's proposals will certainly be the relief of industry from those shorter term anxieties that beset it at the approach of each winter. Contemplation, for instance, of the prospects of fuel and power supply during the coming winter can bring no pleasure to anyone. In last week's issue, in necessarily depressing terms, we discussed the electricity supply situation. Since then the Electricity Sub-Committee of the Joint Consultative Committee has reported. Its report indicates that, far from there being an improvement as compared with last year in the ability of the British Electricity Authority to meet peak load demand during the coming winter months, the situation is expected to be worse. It will be worse in spite of the fact that generating capacity will have increased by some 900MW. On a plant capacity of some 12,000MW in December, rising to 12,200MW in February, the gap between peak supply and peak demand is estimated to reach 1800MW in average weather conditions, 2400MW in cold spells, and as much as 3100MW in really severe weather! Industry is therefore recommended to strive, by load-spreading measures, to reduce the industrial maximum demand by 20 per cent. Thereby a reduction in national simultaneous maximum demand of some 600MW will be brought about, as compared with a corresponding reduction actually achieved of 500MW in 1949/50, and of a reduction of 300MW, which proved far from sufficient, in 1950/51. "This," to quote the report, "leaves at least another 600MW to be reduced by other means," amongst which no doubt it is hoped domestic economies will figure. Yet it is not at all easy to feel sanguine about the extent of domestic savings. For a reference to Ministry of Fuel and Power statistics shows that merchants' stocks of house coal, anthracite, &c., stand at only about two-thirds of the figure at the corresponding date last year, whilst coke is already in such short supply that it has been rationed. If the domestic consumer lacks solid fuel for his fire and his central heating boiler, will he not turn hopefully to electricity for warmth? Nor industrially is the coal situation very appreciably more satisfactory than it was at this date last year. Stocks, it is true, are some 1 million tons larger. But consumption is running, and is likely to run, higher than last year, and last year's stocks proved to be too low adequately to cater for the winter's demand. Nor does the picture we have to paint, of a risk of a serious fuel crisis should the coming winter prove unusually hard, apply only to the next six months. There seems little prospect of any improvement year by year. It is not only in the coming winter that the risk of crisis arises, but in the next and the next and the next as well!

Whatever happens the winter is bound to be harsh. For even if the meteorologists are able to show, next May, that the winter's weather, atmospherically, was mild, homes are likely to go insufficiently warmed and the output of factories and the wages of workers are likely to be reduced by load shedding. Nor, unless there is some change of policy, does there seem much chance for a decade, at least, that winters can be endured without similar hardships. For even with annual increments of generating capacity approaching 1000MW, generating capacity seems to be falling behind rather than catching up upon the increasing demand of Britain's expanding industries for power. Nor even if it can really be reached, which is far from certain, does the output of coal, planned to be 240 million tons in 1961, look sufficient to meet demands unless very substantial economies in coal usage can be made. Is it appreciated, we wonder, that, upon post-war performance to date, it is a conservative estimate to assume Britain's industrial output will have risen by 50 per cent by 1961 with all that figure implies in relation to demands for power, light and heat? And so we come back to consider the work of the newly appointed Power and Fuel Resources Committee. It is true that if its recommendations eventually prove to have the wide scope of the proposals that Sir Claude Gibb has ventilated, they must take much more than a decade to realise. But it would, at least, be some relief to have in course of realisation some plan that offered a promise, more assured than any at present existing, that fuel and power supplies would become adequate within a reasonable period, and that the extensive but still limited reserves of British coal would be used to the best purpose. The pity is that the Government did not act sooner in calling together a body of men who can and will study the problem seriously and, we hope, dispassionately in seeking a satisfactory solution.

PRESERVATION OF RURAL ENGLAND

In 1926 there was founded the "Council for the Preservation of Rural England," a council whose objects are revealed by its title and of which individuals, local authorities, societies, professional bodies, livery companies, banks, industrial firms, &c., can become members. It now has a large number of affiliated bodies and forty branches. Curiously, however, there is no London branch. In this jubilee year, therefore, the Council is not only appealing for those further voluntary contributions for financial support upon which it depends for the continuity of its work, but is also setting up a new London branch.

Engineers, of course, watch the work of the Council with mixed feelings. There have in the past been some occasions on which we, for instance, have felt that criticism of its actions was called for. Indeed, at the present moment, we feel that the Council's opposition to projected hydro-

electric schemes in North Wales is misguided in conception, and based upon exaggerations of the true facts; and that many of the conclusions drawn are wrong-headed and inaccurate. The opinions of the Council, however, are sincerely held, and it is certainly right that if any considerable number of people are opposed to a projected scheme they should have in being an organisation through which they can make themselves heard. For in this country—thank Heaven!—we do not stigmatise those who vocally oppose the actions of the Government, local authorities or big public corporations, as "saboteurs." We respect and applaud them. Moreover, the Council has the power to draw attention to the ways in which the rural beauties of England's countryside can be threatened by unwise industrial or other developments and has frequently used it, with good sense and moderation, to bring about modifications of projected developments undoubtedly with benefit to the community. May it continue to do so! As engineers, we are fond of pointing out that the crowded population of this land could not live without the structures that we erect, and in short, that dams and reservoirs, water supply works and sewage works, power cables and power stations, roads, railways and the like contribute as much to "amenities" as the natural fields, woodlands and mountains which the Council desires to preserve. The truth of that argument is self-evident. But there is a distinction, to which a speaker at a recent meeting of the Council drew attention, to be drawn between amenities that "keep us alive," such as waterworks and sewage works, and amenities that make us "glad to be alive." That distinction is undoubtedly a valid one. It remains valid even though at times there may be dispute about the category to which a particular structure should be assigned. Are we wrong in protesting that the Council seems inclined to regard a dam in prospect as coming within the former class, whereas it may admit that one built should be placed in the latter?

Bodies, such as the Council whose work we are discussing, sometimes seem to look upon engineers as beings unlike other folk, as men with no souls, intent only upon desecrating the countryside! In fact, of course, engineers have as strong a desire to preserve the beauties of rural England as anyone else, even if they interpret the verb "preserve" liberally to mean that though changes must occur to meet the needs of a developing community, there need not thereby be a lessening of amenity. Sometimes it seems to us that the Council, in its efforts to protect the country from desecration, adopts the negative policy of opposing all change, apparently lacking confidence to believe that man, in his new structures designed to "keep us alive," can create new amenities the contemplation of which can also make us "glad to be alive." In consequence, we feel that the work of the Council could be made more effective if that attitude were less in evidence; in short, were engineers to be more fully represented upon it. In wishing the Council success in its appeal, and in the setting up of a London branch which will undoubtedly have many opportunities to prove its usefulness, we hope that engineers will support and take part in its activities.

Literature

The Structure and Mechanical Properties of Metals. By BRUCE CHALMERS. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 18s.

THE object of the series of monographs on metallic materials published under the authority of the Royal Aeronautical Society is presumably to render available to the aeronautical engineer a concise account of those aspects of metallurgical research and development in which he has a special interest. The first volume of the series, on "The Properties of Metallic Materials at Low Temperatures," only dealt briefly with the general underlying theory, but was chiefly notable for its very complete collection and assessment of numerical data relating to the low-temperature properties of a wide range of metallic materials. In contrast with this, the second volume of the series, which is the subject of this review, contains very few numerical data. It is not a reference book. The author takes the far more valuable line of linking up the physicists' approach to the study of metals with that of the engineer, who already has many available sources of information about the heat-treatment and mechanical properties of standard materials but who may not be so familiar with the development of their theoretical interpretation in terms of the structure of metals and alloys.

Professor Chalmers, in a delightfully written monograph, has given a simple, clearly defined picture of the structure of metals in relation to their mechanical properties. Avoiding mathematical treatment and making use of many apposite analogies and illustrative diagrams, he describes the structure of metals and alloys and shows the effect of deformation and heat-treatment on structure. The scope of the book does not allow more than a brief mention of the experimental methods by which structures are ascertained and the implications of the structures determined, but these matters may be followed up in other books, to which references are given.

The last chapter—which comprises about one-third of the book—is devoted to a discussion of mechanical properties and their dependence on structure. This is confined to a qualitative indication of the effect to be expected from a specified change in composition and treatment. The chapter opens with an interesting tabular classification of mechanical tests according to whether they are carried out by single or multiple applications of force, and whether they are non-sensitive or sensitive to time. The properties measured by these tests are then considered in detail. There is an interesting account of the possibility of modifying the Young's modulus of aluminium by alloying. Though it might be possible to raise the value from 10×10^6 to 15×10^6 lb per square inch, the practical limit is set by deterioration of other properties. It appears that a modulus of not more than 12 or 13×10^6 lb per square inch may be combined with reasonably good other characteristics.

In connection with stress-strain relationships of materials, a description is given of the mechanism of the raising of the elastic limit or proof stress by plastic deformation and of the Bauschinger effect, whereby the elastic limit depends on the direction in which it is measured in relation to previously applied deformation. No mention is made, however, of the fact that tensile overstrain temporarily reduces the elastic limit in tension as well as in compression. The effect is transient; in iron it may last for a few days, in high-carbon or alloy steel for years unless a low-temperature tempering treatment is applied. It is only after elastic recovery has taken place that the difference between the elastic limits in tension and compression is fully developed. The Bauschinger effect is explained qualitatively by the existence of residual stresses between the crystal grains. It would be interesting to have, alongside of this, the structural explanation of the other phenomena associated with overstrain, e.g., the temporary fall in the elastic limit measured in the direction of the overstraining load, its restoration by heating at 100 deg. Cent. to 200 deg. Cent., leaving the Bauschinger effect fully in evidence, elastic after-working, and hysteresis loops on unloading and reloading a test piece which has been stretched beyond its yield point—loops which appear to be much less evident with magnesium alloys than with other structural materials.

There is a fairly lengthy discussion of brittle fracture, and with most of it physicists and engineers will be in agreement. The author's remarks on the notched-bar (Izod) impact test, however, call for some comment. He says: "The main practical implication of impact strength is that it is sensitive to the presence of 'dirt' in steel." Passing over the inappropriateness of the term "strength" to denote energy absorbed in plastic deformation, the reader may question whether, apart from the appearance of the fracture, a single impact test gives any indication of the effect of inclusions; although, as Brearley pointed out many years ago, the ratio of longitudinal to transverse impact value is useful in this respect. There is no reference to the utility of the test in controlling heat-treatment or to its unique value in revealing a tendency to brittle fracture. Allowance must, of course, be made for restriction of space, but the author dismisses the subject with the statement that "the impact test only shows what the behaviour would be under quite artificial conditions that would undoubtedly be avoided by the designer of any structure or machine." Would that this were undoubtedly true! But, even so, there still remain errors of machining, damage inducing high localised stress and other accidental stress-raising conditions against the effect of which a good impact value is a most effective safeguard.

These comments are not intended to call in question the excellence of Professor Chalmers' work. The book illuminates so many features of the relationship between structure and properties that it creates a desire for more information and an interest in the outcome of further investigation. In most respects the results of structural studies are purely explanatory of the known facts; in some instances a qualitative prediction of unknown properties has been possible; in others any attempt to generalise would appear to be premature. Professor Chalmers makes no extravagant claims as to the possibility of predicting the actual mechanical properties obtainable in practice; but he has, within the limits which he has set himself, produced a remarkably clear and well-written account of the rela-

tionship between structure and properties, which should be extremely helpful in co-ordinating existing knowledge and suggesting new ideas.

World Railways, 1950–51. Edited by H. SAMPSON. London: Sampson Low, Marston and Co., Ltd., 28, Gilbert Street, W.1. Price £3 3s. net.

ALL students of railways and locomotives will welcome this new work of reference, which is a worthy companion volume to those two world-famous publications, "Jane's Fighting Ships" and "Jane's All the World's Aircraft." It fills a long-felt want in the literature on railways, for it provides under one cover a mass of information on the methods, operation and equipment used on the many and varied rail systems throughout the world. Hitherto, although much of the information it gives was available, it was distributed over a very wide field and could only be traced at the cost of much time and trouble.

The new book is arranged on similar lines to its companion "Jane" volumes, and has been compiled upon information supplied by railway authorities and equipment manufacturers in all parts of the world. In the preface the publishers point out that to attempt to give illustrated details of every individual railway in one book was out of the question. It was decided, therefore, that it would be more valuable to present a detailed picture of a number of the principal systems rather than to give merely a catalogue of them all irrespective of size. Even with the imposition of those restrictions the book contains more than 600 pages of text with 102 maps, nearly 700 photographs, and 420 diagrams.

The concise and detailed information given on the lay-out and main features of the principal railway systems is in many cases accompanied by a map and diagram of the more notable routes covered. Each section devoted to a particular system opens with general notes of interest on the gauge, mileage, leading statistics, permanent way, signalling, &c. Following this general picture the principal kinds of locomotives, carriages and wagon stock are given in tabular form together with photographs and drawings.

The first edition of this volume is published at an early stage in an interesting period in transport history, when the development and construction of the steam locomotive has virtually ceased on a number of important lines and is being replaced by electric and diesel-electric traction. It naturally follows that, with the succeeding editions of the book, which are promised by its publishers, there will be noted a steady decline in the numbers of steam locomotives and a proportionate increase in the number of electric, diesel, diesel-electric, and possibly gas turbine locomotives placed in service in many parts of the world. For this reason the book and its successors will not only provide a valuable means of reference for the railway student of the day, but will be a concise and interesting record for future students of rail transport.

The standard of printing and the quality of the photographs reproduced in this book are of a high order. All interested in railways will look forward to succeeding volumes of what is undoubtedly the finest general work of reference on the world's railways.

FUNCTIONS OF A PERSONNEL DEPARTMENT.—The Institute of Personnel Management, Hill Street, London, W.1, has published a third edition of a booklet by Mr. G. R. Moxon, entitled "Functions of a Personnel Department."

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE RETURN OF THE NATIVE

SIR,—Having only been back in the land of my birth a matter of days, it would ill become me to find fault too captiously—I am only too glad to be back. I want first to look for the good and, as far as possible, overlook the bad. I pass over dirty stations, trains and engines now that the root causes for these all too obvious blemishes have been explained to me, as they have been, by people in a position to know. Apparently there is nothing anyone can do about it at present. But when one sees, as I did, the other day, a splendid engine pull out of a London terminus at the head of one of Britain's crack express trains with a couple of bushels of cinders and ash lying on the footplate just below the smokebox door, it is almost excusable to let fly; there ought to be punishment to fit this crime. Surely that could have been avoided? Was there nobody at the shed with enough *esprit de corps* to take a broom for thirty seconds and sweep away the studied insult to a fine engine and a famous, much-publicised train? When I saw this, like Hiawatha,

> "Then my heart grew hot within me,
> Like a living coal my heart was!"

Quite apart from the look of the thing, these cinders might easily blow into the motion and into the driver's eyes. They certainly got into my hair.

A couple of years ago I suggested in THE ENGINEER that longer and heavier trains might be necessary in post-war Britain, and even outlined a locomotive that could handle them at high speed—a Beyer-Garratt. Needless to say, I did not and do not think there is the remotest chance of such an engine ever being built. The article was merely written as a sort of mental exercise, to stimulate thought and start a discussion, which it certainly did. The correspondence went on about six months; I got a lot of fun out of it and so, I am sure, did many other people. But judging from my brief experience of present-day travel in Britain—as a passenger that is—it looks as though there may have been something pertinent in my suggestions, after all, that longer and heavier trains may become necessary. So far I have made three long-distance journeys in Britain and on each occasion the train was packed; people were standing in the corridors (myself, too, once), their baggage cluttering up that constricted thoroughfare to the point of madness for anyone trying to get to the dining-car, or that other amenity of civilised life that one does not mention in a drawing-room. None of these trains had enough cars on, making travel a wretched business for many of the passengers; furthermore, two of the trains ran very late. Remedy? More cars and a Beyer-Garratt engine to haul them! Where is the money to come from? Why, from the owners of the railways, of course—the taxpayers—the people standing in the corridors—you! Not from me, fortunately—I am only a visitor.

A final point, apropos of crowded trains and cluttered corridors. Taking train from St. Pancras the other day, I put my two suitcases in the front luggage compartment, which is where luggage ought to be put, not piled on exiguous racks and obstructing corridors that are awkward enough to negotiate in any case. At Nottingham, stiff and tired, I got out to stretch my legs and, incidentally, see if my suitcases were all right—they had disappeared altogether. Prompt appeal to guard and lost property office at my destination led to the recovery of the baggage next morning; some genius had dumped it off at Bedford because it had shipping-labels on it, and so, by an evil chance, had two other suitcases next to it. If the American "check" system were in use in Britain, as I think it should be, this annoying contretemps could never have occurred. A numbered "check" with the passenger's destination stamped or written on it, is tied by a looped string to each article and a duplicate given to the passenger, who can then dismiss his impedimenta from his mind and need not see it again until he claims it by presenting his half of the check. Once that check is given him responsibility for the safety of the baggage is solely the company's and only once in a blue moon does anything go astray, and then it can be traced. Were this system adopted in Britain luggage would go mostly in the van, where it belongs; suitcases would not have to be piled on exiguous racks to fall on people's heads when the brakes go on—on mine the other day—and would cease to be an exasperation to people trying to get along corridors. Railway travel would be simpler and pleasanter; everyone would be more care-free and uninhibited, including

EDWARD H. LIVESAY

Sheffield, Aug. 13th.

SHORT NOTICES

Press Tool Practice, Part 4. By P. S. Houghton, A.M.I.Mech.E. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 21s. net.—This is the final volume of Mr. Houghton's comprehensive work on press tools, the first part of which was published some ten years ago. The first three parts dealt very fully with the design and construction of the many types of press tools, presses and press operation. This volume deals in concise detail with the press tools used and the methods followed in the production of various articles of particular interest from the designers' and the tool-makers' angles. A useful glossary of press working terms is given and the volume concludes with a number of questions and problems connected with press tools, which are based upon the information given in the whole series of volumes. The subject matter is well supplemented with drawings and tables. Designers, tool-makers and students who have found the first three parts of this work a valuable source of information will welcome this final volume.

BOOKS RECEIVED

Mind, Life and Body. By R. O. Kapp. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 12s. 6d.

How to Estimate. By J. T. Rea. London: B. T. Batsford, Ltd., 15, North Audley Street, W.1. Price 21s.

High-Speed Small Craft. By Peter Du Cane. London: Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 30s.

Radio Circuits. By W. E. Miller. London: Iliffe and Sons, Ltd., Dorset House, Stamford Street, S.E.1. Price 5s.

Workshop Technology, Part III. By N. A. J. Chapman. London: Edward Arnold and Co., 41 Maddox Street, W.1. Price 30s.

Corrosion Guide. By E. Rabald. Amsterdam: Elsevier Publishing Company, Inc., 118, Spuistraat. Price F.45·50.

Fractional Horse Power Motors. By Stuart F. Philpott. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 30s.

Classical Mechanics. By H. C. Corben and P. Stehle. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 52s.

Calculus. By Lyman M. Kells. London: George Allen and Unwin, Ltd., Ruskin House, 40, Museum Street, W.C.1. Price 28s.

Dielectric Breakdown of Solids. By S. Whitehead. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 25s.

The Engineering Method. By J. C. L. Fish. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 24s.

Modern Interferometers. By C. Candler. London: Hilger and Watts, Ltd., 98, St. Pancras Way, Camden Road, N.W.1. Price 57s.6d.

The Standard-Sunbury Engine Indicator "Mark 6"

By E. S. L. BEALE and R. STANSFIELD

No. I

THE original design of the Standard-Sunbury engine indicator was described in THE ENGINEER in 1935.* Since then considerable numbers have been put into use for examining the behaviour of engines, compressors and many other machines in which there are cyclic changes of pressure and recurrent mechanical movements.

Developed when the application of electronic methods to the solution of engine operating problems was in its infancy, and very much tied to the limits then reached by the simpler forms of radio receiver, the instrument had several defects. Some of these were known from the start, but had to be accepted as limitations not sufficiently serious to make the apparatus unusable; others became obvious as experience increased and as the equipment was put to different uses; then, with the rapid advances in valve and circuit design brought about largely by the war, it was possible to undertake the construction of a new instrument sufficiently accurate for any engineering requirement and, at the same time, commercially practicable. Numerous improvements were, in fact, introduced in a unit built during 1938–39, but war conditions prevented its general adoption; this version was, however, in almost continuous use for several years and served both to emphasise the need for further work and to prove the value of some of its new features. A still later experimental model made during

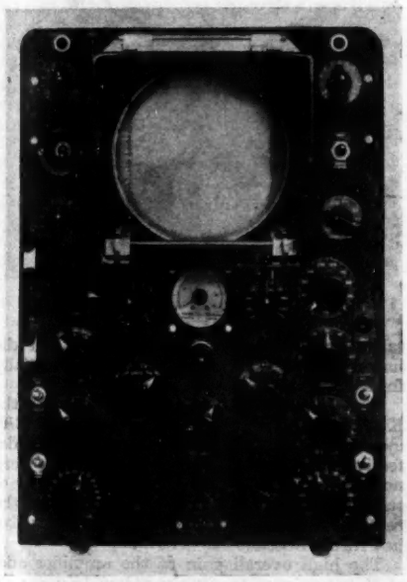


FIG. 1

1945–46 gave additional experience, but proved to be a too ambitious, as well as a rather unsatisfactory, project, and one which could not have been made commercially attractive even had it done what was first expected of it.

The present design is the best practical compromise which could be evolved between the ideal engine indicator which would "do everything" and something which would be of reasonable size and weight so as to be portable, have a small enough power consumption to be run from a battery so that it could be used anywhere, and be simple enough to be made at a reasonable price. The ideal would be for the instrument to be capable of using all the various known types of pick-up—electromagnetic, capacity, photo-cell, resistance strain gauge, piezo-electric—so that each could be used in applications for which it was most suitable. However, such an instrument would be much too large and complicated, because, although some units give an output which can be applied directly to the amplifier, others have to be used in conjunction with special circuits, e.g., modulating systems, or relatively elaborate pre-amplifiers. The better approach, which has been followed in this case, seemed to be to improve one of the most dependable and versatile types of pick-up unit—the simple electromagnetic type—to give an accuracy equal to that of other types, and to incorporate a pre-amplifier suitable for this one type as an

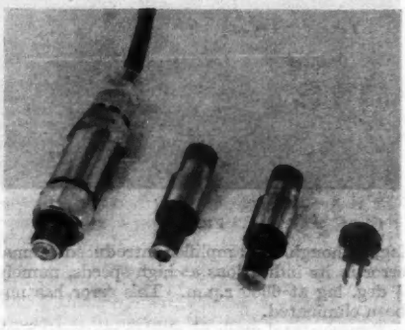


FIG. 2

integral part of the indicator, and then to provide convenient means for attaching any type of pre-amplifier for use with other types of pick-up which may be more suitable for a particular job.

It is, of course, well known that many specialised applications are best met by special designs quite unsuited for manufacture in bulk, and these will always be built to individual requirements. It is equally true that more adaptable apparatus for general use can only hope to be successful if it is developed by, or at least in close collaboration with, engine builders and others who will be using it in its final form. A double-beam tube display is attractive, but there are many difficulties to be faced before it can be made quite satisfactory. There are objections to all available types of double-beam cathode ray tubes and electronic beam switching is probably the best solution; in any case, two amplifiers are required instead of one, and probably additional circuits, so that the price which has to be paid is not small. These complications may not be considered worthwhile provided a single-beam tube can be switched from one diagram to another without delay, especially from the indicator diagram to the degree or time marker. The double-beam indicator is, however, still being developed, and may soon reach a stage at which it becomes practicable, although it will necessarily be of greater size and cost.

Operation from mains requires a highly stabilised voltage supply to cope with mains voltage and frequency variations which are so common. This adds considerably to the cost and size. Furthermore, there are many occasions, which are liable to be overlooked, when a.c. mains supply is not available, as on vehicles or on shipboard. With these considerations in mind, it was thought preferable to run the instrument from a 12V battery, as with the original indicator. In spite of the greatly increased facilities provided in the new apparatus, the current consumption has been reduced to about 3·8A, so that a relatively small battery can be used. Where a.c. or d.c. mains are available it is a very simple matter to provide a small charger, permanently installed, to recharge the battery at the end of a day's work.

With regard to the details of the design evolved on the lines described, the authors have had considerable experience of engine indicating of many different kinds during the last fifteen years, and the present apparatus attempts to embody those features which have been found to be most desirable in a general-purpose engine indicator. One important point in the construction of the amplifiers, &c., is that as far as possible only easily obtained components are used, especially those which may require replacement. The majority of the valves used are of one type. Another aim, to simplify maintenance, has been to make the components easily accessible and replaceable without disturbing other components. Preference has been given throughout to circuits of the simplest type which will give the required performance.

DESCRIPTION OF NEW INDICATOR

The new version of the Standard-Sunbury engine indicator is shown in Fig. 1. It is somewhat larger (12½in by 17in by 18in) and heavier (70 lb) than the old model, the tube unit, the amplifier, and the power supply unit having all been combined in one case. However, the power supply unit has been made self-contained and can be unplugged from the back and carried separately (17 lb). A summary of the general improvements is given below, followed by more detailed descriptions of special features and of the electrical circuits.

(1) *Summary of Improvements.*—The most important improvements are:—

(A) Redesign of the pick-up units, to give high fidelity response, with reduction in size

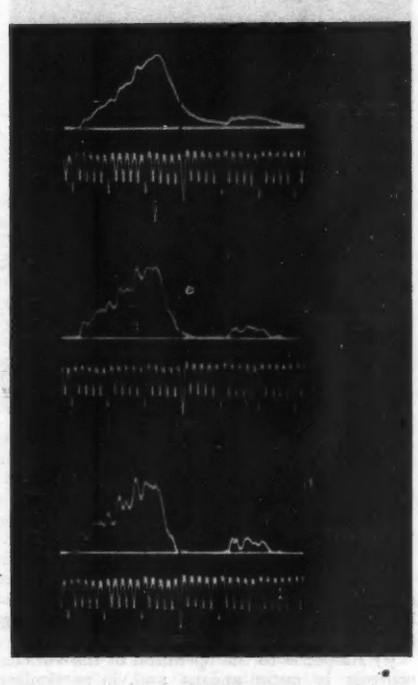


FIG. 3

and more robust construction of the cable connectors, &c.

(B) Redesign of the sweep unit to allow for the use of alternative systems of sweep control and to improve its mechanical details.

(C) Complete redesign of the amplifier, time base and cathode ray tube circuits, to give much better performance and many more facilities.

The chief of these improvements are as follows:—

(*a*) The amplifier inputs and output are balanced to earth (i.e., push-pull), but one side of the pick-ups can now be earthed if required.

(*b*) Float of the diagram has been eliminated except under extreme conditions rarely met with in engine indicating, and even under

* THE ENGINEER, December 13, 20 and 27, 1935.

these conditions the stability is good.

(*c*) The position of start of the sweep is adjustable, but once set, it remains at the same point on the screen for any spread of the time base and at all engine speeds.

(*d*) The main gain control is calibrated in per cent of full gain and is continuously variable down to zero. Individual gain controls are provided for equalising or adjusting the outputs of each pick-up and of the degree and time marker, independently of the main gain control.

(*e*) High-frequency attenuation can be introduced when required on the direct diagram without the introduction of error into the integrated diagram.

(*f*) Various alternative methods of operating the time base are provided, including the self-running condition and synchronising means, which do not require mechanical contacts.

(*g*) A divide-by-two unit is included in the time base, to give when required one sweep every two revolutions of a four-stroke engine, or on either the in-stroke or the out-stroke only of an oscillating mechanism.

(*h*) A time marker (1 milli-sec and 10 milli-secs) is provided in addition to the degree

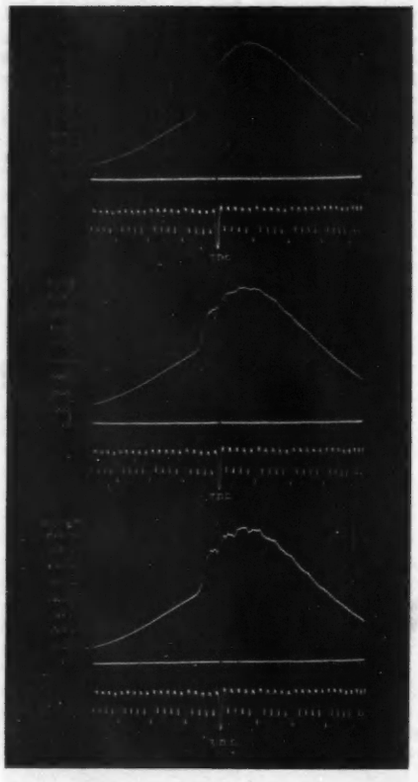


FIG. 4

marker for calibrating the time base, and calibrating voltages can be applied for checking the sensitivity of the amplifier.

(*i*) Response to the operation of the various controls is instantaneous and, in particular, there is an instantaneous switch-over from any indicator diagram to the degree or time marker without any float.

(*j*) High impedance input connections (1 megohm, balanced or unbalanced) are provided to the direct-coupled output stage, and to the first amplifier stage, to enable the indicator to be used as a display unit with other pre-amplifiers for special purposes.

(2) *Pick-up Units.*—A noticeable defect of the early indicator was that the combined frequency response of the pick-up units and amplifier fell off rapidly with rise of frequency, accompanied by a phase lag sufficiently serious to distort certain types of pressure diagram beyond desirable limits. The same cause led to an inaccuracy of spray valve lift diagrams, which gave a false impression of the events just before the end of valve lift and on its reseating. Rapid pressure fluctuations such as those which occur during detonation were almost suppressed or only reproduced in a very attenuated form. Exceptions were: the balanced disc valve or "calibrating unit," which is free from detectable error due to inherent features of its design, and the "degree" pick-up in conjunction with the degree wheel, which has been proved to be itself free from

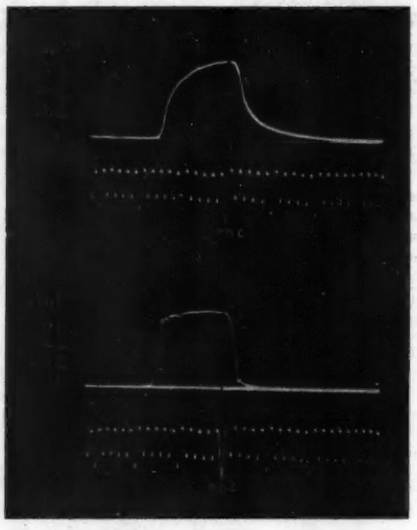


FIG. 5

lag, although the amplifier introduced a small error in its indications at high speeds, namely, ¼ deg. lag at 6000 r.p.m. This error has now been eliminated.

Experimental work on electro-magnetic pressure pick-up units showed that extremely high fidelity was obtainable if a suitably designed permanent magnet bi-pole pick-up was used. A second new electro-magnetic pick-up, not quite as good as the bi-pole, but adequate for nearly all engine work, has also been developed with a single central pole of magnet steel.

Comparative tests made between the bi-pole pick-up and one of the capacity type show

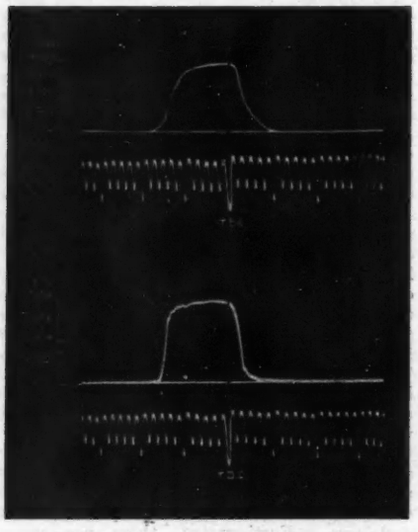


FIG. 6

that while there is little or nothing to choose between them for higher pressures, the magnetic unit maintains its accuracy much better as the pressure range is reduced, presumably because of an increasingly adverse effect of the very small clearance behind the diaphragm in the more sensitive of the capacity units. The disadvantage of the bi-pole pick-up compared with the original soft pole permanent magnet type is that its sensitivity is very much lower, and it is necessary to use a far higher amplification in the amplifier, resulting, in the extreme, in slight instability or float, due to amplifier noise.

The pick-up with the single centre-pole magnet, which is mechanically interchangeable with the bi-pole pick-up, is also less sensitive than the early unit, but gives a considerably greater output than the bi-pole design. Its frequency response is good and the phase shift is small enough to be ignored except in special cases. Fig. 2 illustrates the bi-pole magnet, a centre-pole and a bi-pole pick-up, and a complete pressure pick-up unit with cylinder adapter and cable connector.

Fig. 3 gives three diagrams taken with the original K-type pick-up unit, the new C.P. centre-pole unit, and the new B.P. bi-pole unit respectively. They show the pressure in the fuel pipe of a diesel engine between the pump and the spray valve. These and all the other diagrams were taken at a speed of 1200 r.p.m. At this speed the degree marker wave on the diagrams has a frequency of 3600 c/s.

Fig. 4 gives diagrams taken with the same three units used in a diesel engine cylinder. By comparing these with point-by-point records taken with the calibrating unit the lag in the indications of the three types of pick-up can be measured. At a pressure of about half the maximum the mean error on the compression and expansion strokes can be represented by a time lag of about 3½ deg. of crank angle in the case of the original K-type pick-up, whereas the mean error is less than ¼ deg. for the C.P. unit, and that for the B.P. unit is too small to be measured.

Fig. 5 shows spray valve lift diagrams

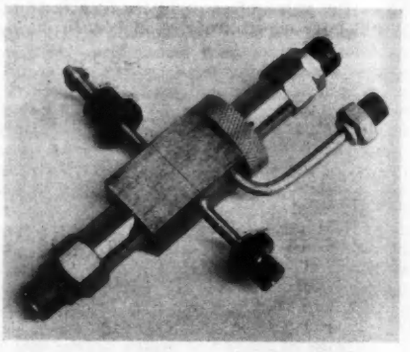


FIG. 7

taken with the original S-type unit and the new centre-pole C.S. design, developed specially for spray valve testing.

Fig. 6 gives similar diagrams taken with the K-type cylinder pressure unit and new C.P. cylinder pressure unit respectively. The defective response of the old designs is very noticeable and the greatly improved fidelity of the new ones is obvious from the shape of the records, when it is appreciated the spray valve had its lift restricted by a stop.

The high overall gain of the amplifier adequately compensates for the reduced sensitivity of the new pick-up units and also makes it possible to dispense with the special large adapters previously used for indicating low pressures either in the engine cylinder during suction and exhaust, or in the manifolds. The cylinder weak spring unit now consists of a centre-pole pick-up assembly modified only by changing the usual single diaphragm to a double one, of which the lower member is from 0·010in to 0·015in thick with a central hemispherical projection towards the pick-up. The upper part is a non-magnetic thick annulus, flat at the top and slightly recessed underneath to allow the thin lower disc to move freely under the action of low pressures and to reinforce it when the pressures rise above weak spring limits. This fitting does not need an air supply for backing purposes and it gives an accurate diagram free from the phase lag which was a serious defect of the old unit.

Not only have the units been improved and their size reduced, but the cable and connectors have received attention, so that they are much more robust as well as neater than before. The type of input sockets on the amplifier is unchanged, to allow existing pick-up leads to be used with the new equipment. Two-core screened cables and connectors are used, as before, but for a different reason. The amplifier circuits now allow one side of the pick-ups to be earthed, but better performance as well as greater freedom from a.c. mains interference is obtained by making the pick-up input balanced to earth, i.e., push-pull.

A new fitting has been introduced for fuel line pressure measurements and is shown in Fig. 7. It takes both a diaphragm with its associated pick-up and a calibrating disc valve and pick-up. This is a most useful auxiliary, enabling the pressure diagram to be calibrated for both peak and residual pressures with the minimum of trouble.

(To be continued)

Prestressed Concrete Tanks

FIVE tanks have recently been built at the Palliser Works of the British Periclase Company at West Hartlepool for the Ministry of Supply, two of them with a capacity of 2 million gallons each, in prestressed concrete. All five tanks are connected with the process of manufacturing sea water magnesia, which is later processed into magnesium metal and into dead burnt magnesite for refractories for the steel industry, sea water and dolomite being the principal raw materials. Two are what are known as half-tide storage tanks, each 106ft in diameter and 41ft deep; one is a sand trap tank, 50ft in diameter and 46ft 6in deep; and the other two, both reaction tanks, each 30ft. in diameter and 36ft deep. The manufacturing process is a continuous one. First, the sea water is pumped into the sand trap tank and is passed over a circular weir into an elevated annular launder and then on through flumes into the half-tide storage tanks, which normally are filled and emptied twice a day, since pumping of sea water can only take place between full and half-tide conditions. The sea water is mixed with dolime and then enters the Dorr hydrotreaters, where the calcium compounds are removed, from where it passes into reaction and settling tanks, where the magnesium hydroxide is collected ready for filtering and calcining in rotary kilns.

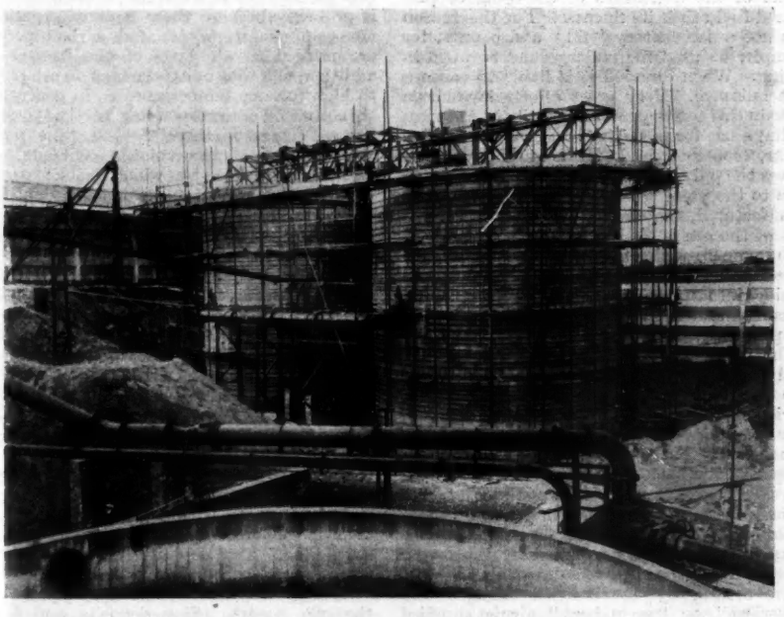
The prestressed concrete tanks have been built according to the Magnel system. The sequence of prestressing was to tension first the vertical cables and then the horizontal ones. The horizontal cables are composed of groups of four high-tensile wires of either 0·200in or 0·276in diameter, depending on the diameter and depth of the tank. These wires lie in a layer, one wire thick, against the external concrete surface; they were supported in position prior to tensioning by a series of 1in by 16-gauge mild steel vertical strips with notches cut in them to ensure the correct spacing of the cables throughout the height of the wall.

When the horizontal cables had been tensioned a light steel reinforcing mesh was fixed to them and a 1in thick coat of mortar was applied pneumatically over the whole outer surface of the tank walls as a protective covering to the high-tensile wires and their anchorages. The mortar also serves to bond the wires to the prestressed shell. The accompanying illustration shows two reaction tanks ready to receive the coating of pneumatic mortar. A typical cross section of a tank is shown on this page.

The vertical prestressing was carried out with ordinary Magnel-Blaton cables which were located at the mid-thickness of the walls. For the storage and sand trap tanks these cables were composed of sixteen 0·200in diameter wires and for the reaction tanks eight-wire cables were used. These cables were placed in position prior to concreting and the lower anchorage was then cast in with the first lift of the wall.

All the tanks were designed with a sliding joint between the walls and base, the joint being formed by constructing a groove in the base and then casting the wall in it. All have a number of pipes passing through the walls and suitable holes were left to accommodate them. Because of the number of large pipes which pass into the storage tanks at floor level it was decided to design the base and bottom 6ft height of the wall, together with the low-level launder which surrounds these tanks to collect overflow, in normal reinforced concrete. This overcame the problem of having the continuity of the lowest rim of the prestressed shell interrupted by the holes through which the pipes pass.

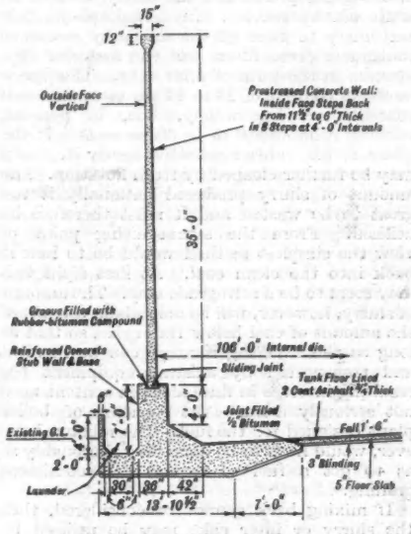
The inner surface of the prestressed concrete in all the tanks is without protective coating of any kind, and is in direct contact with the contents of the tank.



REACTION TANKS NEARING COMPLETION

The lower anchorage for the vertical cables of the reaction tanks comprises a short mild steel bar, to which are welded several ¼in mild steel links. Each high-tensile wire in the cable passes from the top anchorage around this bottom anchor bar and back to the top. As mentioned previously, the anchor bar and the lower 1ft 6in of cable were cast in the concrete of the first wall lift. The upper anchorage comprises the standard sandwich plates and distribution plate, and tensioning of the cables was carried out by the normal Magnel-Blaton jacking equipment similar to that used for beam work. The 0·200in diameter wires are of 100/110 tons per square inch ultimate strength and they were tensioned to 140,000 lb per square inch.

The anchorages for the horizontal cables are the opposed sandwich plates, which have their four grooves arranged sc that when the eight



SECTION THROUGH STORAGE TANK

ends of wires are secured the plate is in equilibrium and lies flat against the tank surface. Tensioning was carried out by the Magnel-Blaton tank jack, which straddles the sandwich plate and simultaneously pulls two wires from each direction around the tank. When the calculated extension had been induced in the wires the wedges were placed and they were secured in the grooves of the sandwich plate. The horizontal cables are of 95 to 105 tons per square inch ultimate tensile strength.

To allow for loss of tension due to friction of the wires against the concrete, in the most highly stressed position near the bottom of the storage tanks, tensioning and anchoring the wire cables was done simultaneously at four points 90 deg. apart. Only near the bottom of the large tanks was four-point tensioning employed; in all other cases the wires were tensioned at two points 180 deg. apart. The anchorages of adjacent cables are spaced at intervals around the circumference to provide a uniform effective prestress in the shell.

Construction followed the usual practice for water-retaining structures as far as the concrete work was concerned. The mix specified was a nominal 1 : 1½ : 3 with a water-cement ratio of 0·45. Shutter vibrators were employed to compact the concrete in the prestressed walls and launders, immersion vibrators being used for the reinforced concrete stub walls and bases. Normal Portland cement was used, and throughout the contract the average twenty-eight-day test cube strength was approximately 6500 lb per square inch. The contractors were Costain-John Brown, Ltd., and the prestressing equipment was by Stressed Concrete Design, Ltd.

B.E.A. CONTRACTS.—The British Electricity Authority states that during the past month it has placed contracts for equipment for power stations, transformer stations and transmission lines amounting in the aggregate to £3,237,052.

The Design of Large Boiler Plant for Using High-Ash Coal*

By W. G. MARSKELL, B.Sc., F.Inst.F.†

It must be borne in mind that coal cleaning introduces its own problems. Present-day mining methods produce a lot of fines and dust, and in order to suppress dust underground, wetting with water sprays is extensively used. Wet cleaning methods are, therefore, the only feasible means of reducing the ash content and result in aqueous suspensions of the fine material in the washery water which in the concentrated form is known as "slurry." Some 10 per cent of the national production of coal is less than ¼in in size and some 5 per cent of the output from a washery will appear as slurry. In the older washeries, the washery water is run into settling ponds and the slurry allowed to settle out by gravity. In modern plant, it is customary to filter off the slurry by means of continuous-drum filters and the material then appears in the form of filter cake. This has a moisture content of 25 to 33 per cent, with ash contents varying widely, but, in general, running from about 15 to 30 per cent. If the quantity and other conditions justify it, slurry may be further cleaned by froth flotation. The amount of slurry produced nationally is too great to be wasted and it must therefore be utilised. From the steam-raising point of view the simplest method would be to mix it back into the clean coal. At first sight this may seem to be a retrograde step. The amount of slurry, however, will be only about a tenth of the amount of coal below 1in in size, so that as long as the resulting mixture can be handled and transported by existing equipment the resulting increase in fines and ash content need not seriously disturb the economy of boiler plant designed for the fuel. The mixing, however, would have to be done very thoroughly so as to get a fuel of regular and consistent grading.

If mixing back cannot be considered, then the slurry or filter cake may be utilised by itself. This is, of course, a more difficult problem as the combined ash and moisture contents may be as high as 60 per cent. It is quite uneconomic to transport such low-grade material, so that it must be utilised at the point of production. The problem of utilisation is largely one of handling and drying the material. In modern plant on the Continent it is utilised on specially designed boiler plant by feeding it into special pulverising mills, through which high-temperature flue gas is passed. As the material is already very fine, the mills are not called upon to pulverise the material so much as to agitate and dry it. The milling and boiler plant, however, is of very special type and must be fairly large to justify the capital expenditure. The electrical power generated is far in excess of the associated pit and washery plant requirements and must be an integral part of the public service supply. It must be borne in mind, however, that the conditions met on the Continent are somewhat different from those in Britain.

The mineral matter in coal may be divided broadly into the inherent mineral matter and the extraneous mineral matter. The inherent matter is that which is inextricably mixed with the coal substance and cannot be separated by normal means. A good deal of the inherent mineral matter is associated with the mineral matter contained in the original vegetable material or in material laid down along with it at the time of deposition. This matter is high in compounds containing sodium, potassium, calcium and iron. The resulting ash, therefore, tends to have a low fusion temperature. The extraneous mineral matter consists largely of shale and similar material. As this consists largely of aluminium silicates, the resulting ash is comparatively high in fusion temperature.

The increase in ash content which has resulted from a change in mining methods and lack of cleaning facilities has largely resulted from the extraneous mineral matter. High ash content is, therefore, not necessarily associated with a more fusible ash; in fact, the reverse is generally the case. The increased ash content in present-day coal supplies has therefore been more of the nature of an inert diluent and has not, in general, involved any special problems in the formation of fused slags and deposits. It can be stated with confidence that boiler plant can be designed to utilise any material with sufficient heating value to support combustion. There must be a point, however, when the capital charges and other costs would far outweigh the value of the steam raised.

For economic and technical reasons boiler plant in electrical generating stations is now very large. Boilers capable of evaporating 200,000 lb to 300,000 lb of water per hour are common and there are boilers capable of evaporating as much as 800,000 lb to 1,000,000 lb of water per hour. A boiler with an evaporation of 500,000 lb. of water per hour will consume some 28 tons of coal per hour and will produce some 5½ tons of ash per hour when using a coal with an ash content of 20 per cent. The handling of such quantities of fuel and ash is, of course, entirely mechanised. The handling and disposal of large quantities of ash is in many cases a big problem and the form in which the ash is obtained is an important factor. The various methods of burning coal on large boilers produce ash of varying physical types and the form in which the ash is obtained may play a big part in deciding what type of firing is adopted.

The most usual method of firing coal on large boilers is either by mechanical stokers or as pulverised fuel. Mechanical stokers are, in general, used for boilers of less than 250,000 lb per hour evaporation. For larger boilers pulverised fuel is almost exclusively used. When firing coal by mechanical stokers, the bulk of the ash remains on the grate and is mechanically discharged to the ashpit, largely in the form of partly sintered clinker. In some areas, mechanical stoker ash can be sold for making up land and roadways and for similar purposes. Even in cases where it is to be dumped it can be relied upon to stay in place and not be blown away by high winds or washed away by heavy rain. In pulverised fuel firing, however, all the coal is ground very fine and is airborne in the furnace. The resulting ash is therefore largely airborne and a good deal of thought has had to be given to the problem of separating the maximum amount of ash in a form which can be readily handled. The flue gases, even when the major part of the ash has been separated, are still very dusty and must be cleaned by elaborate and expensive precipitator plant if atmospheric pollution is to be avoided.

One of the difficulties of disposing of pulverised fuel ash is its fineness. For this reason it is not a satisfactory "fill" and cannot, for example, be used for underground stowage in mining. When dumped it is liable to cause a dust nuisance. Very great efforts have been made in this country, and especially in America, to find a use for pulverised fuel ash for making bricks, concrete and for similar purposes. Unless the pulverised fuel fired plant is situated close to the point where the products are to be manufactured, the cost of handling and transport of the ash is likely to make it difficult for it to compete with other materials. With the increased amount of pulverised fuel fired plant coming into use there is little possibility of utilising more than a small proportion of the ash produced.

The most usual form of mechanical stoker used in this country is the travelling grate. The grate consists essentially of short bars carried on a very wide endless chain passing over sprockets in the front and rear of the furnace. The coal is fed on to the grate from a hopper at the front of the boiler. As the coal travels into the furnace it is ignited by heat radiated from the furnace. Air for combustion is supplied through the upper strand of the grate from a windbox supplied by the forced draught fan. The gases are drawn through the boiler setting by the induced draught fan. "overfire" or "secondary" air is supplied above the fuel bed to complete the combustion of gases rising from the fuel bed. The fuel burns during its passage through the furnace and the resulting ash is discharged from the rear of the stoker into the ashpit.

The mechanism of combustion on travelling grates has been the subject of much detailed investigation. It has been established that the fuel bed on a travelling grate may be divided into three zones: (1) the ignition zone, where the ignition plane is travelling through the bed, leaving behind a bed of incandescent coke; the gases above this part of the fuel bed are smoky owing to the hydrocarbons being distilled from the fuel bed; (2) the combustion zone, where the coke bed is burning. It burns from the bottom upwards and the fuel bed is very hot. The gases above this part of the fuel bed are free from hydrocarbons and therefore are free from smoke. (3) The burning-out zone, where the last part of the carbon is burned from the ash before discharge. The gases above this part of the bed are also smoke-free.

British coals contain appreciable amounts of sodium and potassium and may contain smaller, but significant, quantities of other volatile elements, such as boron, arsenic, &c. The fuel bed temperatures attained in the ignition and combustion zones are amply high enough to volatilise the alkali metals, particularly when chlorides are present. The volatilised alkali and other metals carried by the gases may react with oxides of sulphur and phosphorus in the gases and condense on boiler and superheater tubes and other comparatively cool surfaces as sulphates and phosphates, cementing together fly-ash particles which would not otherwise adhere to these surfaces. Troublesome deposits, known as "bonded deposits," may thus be formed which may necessitate shutting down the boiler for special cleaning. It has been found that while the alkali metals are volatilised from the fuel bed in the ignition and combustion zones, the presence of hydrocarbon smoke in the ignition zone appears to inhibit their appearing as troublesome deposits. It has thus been concluded that it is, in general, the material in the gases from the combustion and burning-out zones of the fuel bed which are responsible for the formation of these bonded deposits. In 1943, the author and co-workers were able to establish that if liquid fuel is burned over the rear of a stoker so as to introduce smoke into the gases which are normally free from smoke, the formation of deposits may be largely suppressed. Similarly, the introduction of turbulence in the gases above the fuel bed so as thoroughly to mix up both the clear and the smoky gases has a pronounced ameliorating effect on the formation of deposits.

With pulverised fuel firing the formation of bonded deposits is not a major problem. This is probably because there is no segregation in the combustion process and carbon particles are present in all parts of the furnace. In addition, the time of exposure of an ash particle to high furnace temperature is, in general, less than that of a corresponding particle in stoker firing. There is therefore less time for the volatilisation of the volatile elements. The exact mechanism by which smoke particles suppress the formation of bonded deposits is not clear. The most likely explanation is that the alkali vapours condense on the carbon particles. The carbon particles subsequently burn, but at much lower temperatures than those encountered in the fuel bed. The alkalis are therefore not re-volatilised, but are left in the gas as a very fine dust. In the laboratories of the author's firm an investigation of deposits has shown that the sintering temperature of a bonded deposit is always lower than the sintering temperature of dust in the same vicinity. The sintering temperature of the deposit and the sintering temperature of the dust are respectively lower and higher than the flue gas temperature in the vicinity.

In addition to bonded deposits there are, of course, the ordinary accumulations of partly fused slag. Slag deposits form when the gas temperature in the vicinity is higher than the softening temperature of the ash particles in the gas stream. Slag deposits and bonded deposits are most troublesome when they occur

* Paper read before Section G, of the British Association at Edinburgh on August 9, 1951. Abstract.

† Babcock and Wilcox, Ltd.

within banks of tubes where they are very difficult to remove. An obvious way to avoid formation of slag deposits within banks of tubes is to cool the gases down sufficiently before they enter the tube bank so that slag particles are not soft enough to stick. A very noticeable feature in modern boiler design as compared with older designs is that the furnaces are almost entirely water cooled and are very tall. A very large proportion of the heat absorbed by the boiler is absorbed through the furnace walls, while the heat absorbed by convection in the tube banks is correspondingly reduced. One of the effects of this change of design is to cool the gases below a certain critical figure before the gases enter the tube banks. This has very largely elminated slag deposits on the convection surfaces. Slag deposits on the furnace walls, if they adhere to any extent, usually build up to an equilibrium thickness, the outer layers becoming progressively hotter until they become molten, or slag layers break away before building up to a troublesome thickness. In cases where slag accumulates on walls to an inconvenient amount it is fairly easily removed by steam or water jets.

It has been realised for a considerable time that the avoidance of ordinary slag deposits is largely a question of proper disposition of heat-absorbing surfaces. Evidence is accumulating which indicates that it is also important in avoiding bonded deposits in superheater and boiler tube banks that the gases should be cooled below certain critical temperatures before entering the tube bank. It is as yet difficult to assess in each case what these critical temperatures are likely to be because of the segregation of the volatile ash constituents. The gases when they pass through the economiser and air heater prior to discharge to the stack are at temperatures approaching the acid dewpoint. It is important that they should not be cooled too much, otherwise troublesome deposits of acid, sulphates and phosphates can be formed. There is thus a critical temperature range for the gases in the boiler, superheater, economiser, and air heater passages if troublesome deposits are to be avoided.

Another development designed to avoid troublesome deposits is to arrange the convection heating surfaces with comparatively wide gas passages, so that the deposits do not interfere so readily with the passage of gas. The wider passages also render cleaning by steam soot blowers and water lances comparatively easy. It must be appreciated, however, that the provision of wider gas passages may increase the size and cost of the boiler very materially. A considerable part of bonded deposits is water soluble so that the deposits can be generally disintegrated by washing the boiler surfaces with water or by soaking in a steam atmosphere during shut-down periods. Boiler designs now make provision for such washing processes if they are likely to be necessary.

Pulverised fuel fired boilers in this country are not subject to the formation of bonded deposits and can therefore run for long periods without it being necessary to shut them down for hand cleaning. Pulverised fuel fired furnaces may be divided into two classes, one class being known as "dry bottom" furnaces, the other "wet bottom," or more usually "slag tap." In the first, the disposal of the cooling surfaces is such that the ash settling out in the furnace is in a solid form. In a slag-tap furnace, the ash is allowed to fuse and to collect as a pool of molten slag at the bottom of the furnace. The slag is tapped off and disintegrated into granular form by the action of water jets impinging on the slag stream. With the dry bottom furnace only about 25 per cent of the ash is caught in the furnace. With the slag-tap furnace about 50 per cent of the total ash is collected in the slag pool. In both cases the rest of the ash separates out as dust in the gas passages, where suitable collecting and disposal points must be provided. Finally, the gases which carry a very heavy fine dust burden must pass through mechanical dust separators or electrostatic precipitators of high efficiency before discharging to the stack.

It will be seen that while slag-tap furnaces are a step in the right direction, they are only a partial solution of the problem. In addition, the ash must have a consistent and comparatively low fusion temperature and the rate of firing of the furnace must be maintained in order to keep the slag pool fluid. Variation in the steaming rate and the frequent starting up and shutting down of such boilers is to be avoided. These conditions are difficult to satisfy in this country. Large boiler plants must obtain coal from a variety of sources, so that the fusion temperature of the ash is liable to vary within wide limits. The night and week-end electrical demand is also small compared with that required during working hours, so that boilers must be able to cope with wide variations of load.

In an effort to increase the percentage of ash retained in the furnace and to decrease the quantity passing through the gas passages of large boilers a system of firing known as the cyclone furnace has been introduced in America and has met with considerable success. The cyclone furnace consists of a cylindrical water-cooled chamber, the axis of which is slightly inclined from the horizontal. Crushed coal, about ¼in in size, is blown tangentially into the cyclone by a high-velocity air stream. The centrifugal action throws the fuel against the wall of the chamber. The rate of combustion is very high, so that the walls of the chamber are covered with a layer of fused ash. The coal particles stick to the ash layer and the high velocity of the air stream past the coal particles results in a very high rate of combustion. The molten slag is tapped off at the lower end of the cyclone on to the bottom of a primary furnace, from which it drips and is disintegrated by water jets as in slag-tap furnace operation. There may be more than one cyclone furnace to each boiler, discharging into the primary furnace, which is a small chamber lined with water-cooled refractory. The primary furnace chamber, in turn, discharges into a large water-cooled chamber very similar in appearance and design to the furnace of a normal pulverised fuel fired boiler, the port of connection between the primary chamber and the secondary chamber being arranged with a screen of studded tubes which act as slag scrubbers. If variation in the rate of firing required is greater than can be accommodated by varying the rate of firing of each cyclone, one or more cyclones may be shut off. Operating experience shows that cyclone firing retains approximately 90 per cent of the ash in the furnace. This very greatly simplifies the problem of cleaning the flue gases, as the cleaning plant is only required to deal with a fraction of the amount of material present in the gases from a pulverised fuel fired boiler.

Earlier in this paper it was stated that travelling grate stokers are most suitable for boilers of less than about 250,000 lb per hour evaporation, while pulverised fuel firing or cyclone furnace firing is the only feasible method for firing boilers with evaporation greater than 250,000 lb per hour. Boilers of less than 250,000 lb per hour evaporation can be fired by pulverised fuel, but mechanical stoker firing is generally cheaper. Both methods of firing have their own special advantages and limitations. In an effort to combine the advantages of both forms of firing twenty boilers of about 200,000 lb per hour evaporation are being put into commission in this country in which spreader stoker firing has been adopted. Fourteen of these boilers are already operating. In spreader firing the coal is thrown into the furnace by means of rotating paddles or by air jets. The finer particles burn in suspension, while the larger particles fall on to the grate and complete their combustion there. For large boilers it is usual to combine the spreader method of firing with the use of a travelling grate which removes the ash continuously. The mode of combustion on a spreader is very different from that on a travelling grate stoker. The fuel is spread evenly over the whole grate area and ignites and burns in a uniform manner. There is no segregation laterally into the ignition zone, combustion zone, &c., as there is on a travelling grate stoker. The conditions over the whole of the grate are uniform and the gases above the fuel bed are uniformly smoky. The high-temperature zone of the fuel bed is at the surface and, in general, it is at a somewhat lower temperature than that experienced on ordinary travelling grate stokers. The high-temperature zone is also quite thin, so that the ash material is not subjected to a high temperature for so long as it is in travelling grate firing. There should therefore be far less volatilisation of alkalis and this, combined with the inhibiting effect of the smoky gases in the furnace, should very much reduce the incidence of bonded deposits on the heating surfaces. The ash discharge from a spreader-fired furnace is very much less sintered than the ash from a travelling grate or retort type stoker. A considerable amount of grit is carried away from the furnace by the hot gases, but this is readily caught by cyclone type grit arresters, and so far there is no indication that more elaborate cleaning methods, such as electrostatic precipitators, will be necessary.

It is hoped that this brief survey has given an appreciation of the general problem. Large boiler plant is costly and, in general, must be designed for an economic life of twenty years. It is therefore essential to know the conditions it is likely to meet during its life. While boiler plant can be designed to burn any commercial fuel with reasonable efficiency, a given plant cannot burn an unduly wide range of fuels with equal efficiency. It can be just as uneconomic to feed coal of low ash content to boiler plant designed for a high ash content coal as it is to fire high ash content coal to a plant designed for one of low ash content. It is rather like trying to run a racing car on kerosene and a tractor on high-octane spirit. With the nationalisation of mining and transport it ought to be easier to get a more comprehensive picture of future coal supplies than was the case when a multiplicity of interests was involved. The problem of the boiler designer and boiler operator should therefore be correspondingly eased.

Trolleybus Tractive Resistance

THE manufacturers of trolleybus electrical equipment who are members of the British Electrical and Allied Manufacturers' Association have recently taken a valuable step towards standardisation by obtaining a correct trolleybus tractive resistance curve. A comparison of the tractive resistance figures previously used by the different manufacturers in calculating vehicle performance revealed considerable divergence and it was found that very little test data on trolleybus tractive resistance were available.

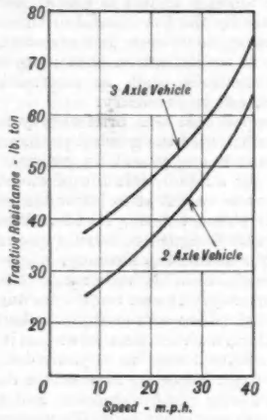
As the actual value of tractive resistance greatly influences the performance of the vehicle, particularly the balancing speed, it is important that tendering companies should use accurate figures in order that the performance as shown by the calculated run curve can be obtained on the actual vehicles. It was, therefore, decided that all the companies concerned should combine to obtain tractive resistance curves from actual tests on trolleybuses.

It was realised at an early stage that no purpose would be served by making motoring tests as all the necessary results could be obtained more simply and more accurately from coasting runs, the reasons being as follows.

It is possible to obtain only one point on a tractive resistance curve by making a run at a balancing speed under power. However, a coasting run gives points over the whole range of speeds through which the bus has coasted. Thus a very large number of motoring runs would have to be made to obtain a complete curve of tractive resistance while only a few coasting runs are needed. Also, tractive effort cannot be measured direct without special apparatus and, in fact, the electrical input to the motor must be measured and converted to tractive effort by means of the motor characteristic. This introduces the possibility of several errors, which are not present in coasting.

The first series of tests was undertaken at

Hastings on a two-axle, double-deck trolleybus. The reason for the choice of Hastings was the stretch of straight, well-made level road along the sea front. Three forms of recording instruments were used on these tests in order to compare and, if necessary, obtain average values of tractive resistance. The three instruments were a two-element cathode-ray oscillograph, a three-element Duddell oscillograph, and a paper strip recorder marked by means of intermittent sparks from two sparking coils. One spark was fired at equal intervals of distance covered by the trolleybus while the other was fired at equal intervals of time. Distance impulses for the recorders were provided by means of a "fifth wheel" apparatus towed



TRACTIVE RESISTANCE CURVE

behind the trolleybus. The variables recorded were speed, time and distance. Several runs were taken in each direction. There was no noticeable wind.

A great deal of work was done in analysing the results of this first series of tests, and two main factors came to light in the process. First, the results obtained from the three recorders were remarkably consistent. Secondly, the Duddell instrument proved to be the most useful in that photographic records of comparatively long runs could be made, whereas this did not prove possible with the cathode-ray oscillograph or the paper strip recorder.

The second series of tests was carried out in London on the L.T.E. system between Kingston Bridge and Hampton Court. A three-axle, double-deck trolleybus was used for the tests. The Duddell recorder only was used in conjunction with a "fifth wheel" apparatus. The road was sensibly level and straight and the surface was good. Nevertheless, a survey was taken and due allowance made for the gradients in calculating the coasting retardation (a gradient of only 1 in 400 which is normally negligible in trolleybus work will introduce an error of over 5 lb per ton). Several runs were taken in both directions to nullify the effect, if any, of the slight wind. On the oscillograph were taken recordings of speed, time and distance, the speed trace serving merely as a guide.

On plotting the tractive resistance figures obtained from the two series of tests as pounds per ton against speed, it was seen that there was a large difference between the curves for the two-axle and three-axle trolleybuses, the latter curve being the higher. Probably the factor accounting for most of this was the difference in the losses of the gears and the effect of the extra rear axle.

The loss in the gears can be split up into gear face loss and oil churning loss. The former is a function of power transmitted whilst the latter is purely a function of speed. Thus, the gear face loss is properly shown on the motor characteristic, while the churning loss is obviously incorporated in the tractive resistance curve as it is a considerable drag on the trolleybus and is included in the resistance measured in coasting conditions. In view of the fact that the power taken in driving the motor during coasting is very small, the gear face loss is even smaller and can be neglected. The difference between the motoring tractive resistance and the coasting tractive resistance is the sum of the motor loss and the gear face loss. This additional loss is accounted for in the traction motor characteristic and should not be included in a motoring tractive resistance curve.

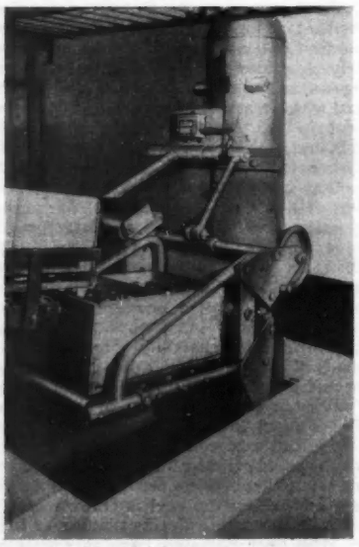
Though the tests were made only on double-deck trolleybuses, the curves obtained should, in fact, be applicable to single-deck trolleybuses. Since the frontal area of a single-deck bus is smaller than that of a double-deck bus the portion of the total resistance which is due to wind resistance will be less for the single-deck bus, which would give a slightly lower figure for the total tractive resistance in pounds per ton. This being so, the use of the test curves in calculating the performance of a single-deck bus will err slightly on the pessimistic side.

As the gear loss has been divided in two, and the churning loss included in the tractive resistance curves, the gear face loss has to be included in the motor characteristic and is to be specified at 5 per cent—that is, 5 per cent of the input to the gears. In motoring, this will be the output from the motor and in rheostatic and regenerative braking, the output from the axle(s). For predicting the coasting retardation a figure of 0·4 m.p.h./p.s. should be used. It was felt that the range of speeds over which trolleybuses normally coasted was so small that a fixed value was justified.

In conclusion, the manufacturers wish to express their appreciation to the Hastings Tramways Company and the London Transport Executive for the loan of trolleybuses and depot facilities, and to Birmingham City Transport for the loan of its "fifth wheel" apparatus.

A Gravity Operated Lowering Machine

THE illustration below shows the upper part of a machine which has been developed by the British Wedge Wire Company, Ltd., of Academy Street, Warrington, for lowering goods safely and speedily from one floor level to another. Known as the "Aircush Lowerator," it is shown installed in a premises where crates of bottles are received from a gravity roller conveyor and lowered to the floor below, where



LOWERING MACHINE

the crates are discharged. The machine is fully automatic and requires no power as it is entirely gravity operated. It occupies a space of less than 8 square feet.

The machine consists essentially of a cylindrical tube or pillar extending from the upper to the lower floor level, through a small aperture in the floor. A light carriage running on guide rails mounted on the pillar is designed to accommodate the articles to be lowered. A piston in the pillar is coupled through a wire rope to the carriage and this piston counterbalances the weight of the carriage and its load. When the load is rolled on to the carriage the combined weight draws the piston up inside the pillar as the load descends to the lower level. The air displaced by the piston as it moves up the pillar escapes through a series of ports.

As the carriage nears its lowermost point the piston passes the last port in the pillar and a cushion of air is formed at the top of the pillar to bring the carriage gradually to a stop. At this point the carriage is tipped forward slightly for the load to roll off the platform.

Once the load is off the platform the carriage begins to ascend and the heavy piston drops by gravity down the pillar. As the carriage reaches its uppermost station the air cushioning process is repeated. A selector device at the head of the machine is tripped by the carriage to free the next crate on the feed roller conveyor so that it automatically gravitates on to the carriage platform for the next lowering cycle.

The makers state that the number of articles lowered per hour on this machine depends upon the length of drop, but the unit illustrated handles 400 crates of bottles an hour.

Clayton Fellowships and Grants, 1951

UNDER the Clayton bequest, the Institution of Mechanical Engineers has recently made the following awards for post-graduate training or research in mechanical engineering. The awards amount in all to about £3800 for the year 1951.

The successful candidates were :—

Clayton Fellowships, 1951.—Mr. B. E. L. Deckker, B.Sc., G.I.Mech.E., Birmingham, for research on wave action occurring in the exhaust pipe of a two-cycle oil engine, with special reference to the scavenging process; Mr. F. Ellis, B.Sc., G.I.Mech.E., London, for experimental and theoretical examination of stress distribution in hot and cold rolling; Mr. J. Halling, B.Sc., G.I.Mech.E., Mitcham, for an experimental investigation of rolling friction in relation to surface finish and loading; Mr. J. Houghton, B.Sc. (Eng.), G.I.Mech.E., Coventry, for experimental and theoretical investigation of the effect of end constraint on thin-walled and solid cylinders of hyperbolic aerofoil shape, with special application to turbine blades; Mr. D. Howe, G.I.Mech.E., Lanchester Hall, College of Aeronautics, Bletchley, for an investigation reviewing certain existing knowledge on loads and stresses in swept-back aeroplane wings, with special reference to its availability to designers; Mr. G. Moss, B.Sc. (Eng.), G.I.Mech.E., London, for an experimental and theoretical investigation of a method of continuous filtration; Mr. H. Naylor, B.Sc., G.I.Mech.E., Baildon, Yorks, for research on lubrication in wire drawing; Mr. M. Ruddick, B.Sc. (Eng.), G.I.Mech.E., Grays, for research on heat transmission in the cooling of gas turbine blading.

Clayton Grants, 1951.—Mr. J. Huddart, A.M.I.Mech.E., London, for investigation of high amplitude pulse transmission in pipe-lines, with special reference to internal combustion engine exhaust systems; Mr. D. R. S. Rabley, B.Sc. (Eng.), A.M.I.Mech.E., Plymstock, Plymouth, for a post-graduate course in photo-elastic methods; Mr. N. D. Thomson, B.Sc., G.I.Mech.E., Sheffield, for a tour of observation of steel works and rolling mills in this country and on the Continent.

F.B.I. INDUSTRIAL RESEARCH CONFERENCE.—Last November, the Federation of British Industries organised a conference of industrial research directors and managers to discuss the planning and financial control of industrial research. It was the second conference of its kind, and a full report of its proceedings has now been published by the Federation. The report, price 3s., may be obtained from the offices of the Federation, 21, Tothill Street, London, S.W.1.

Launch of the S.S. "United States"

THE "United States," the largest and fastest passenger steam ship ever built in America, was launched at the yard of the Newport News Shipbuilding and Dry Dock Company, at Newport News, Virginia, on June 23rd. The vessel, which is shown in the accompanying illustration, has an overall length of 990ft, a moulded beam of 101ft 6in, a depth from keel to the top of the superstructure of 122ft, and a total of twelve decks. The 51,500-ton liner has high-pressure, high-temperature steam turbine propulsion machinery and is driven by quadruple screws. She has a total cargo capacity of 148,000 cubic feet, of which 48,000 cubic feet are refrigerated. The vessel is expected to carry a total of 2000 passengers and a crew of 1000 and in the event of an emergency she can be converted to carry 14,000 troops. The concept of an American "superliner" grew out of meetings held shortly after the end of the last war between officials of the United States Lines, the U.S. Maritime Commission, and Gibbs and Cox, Incorporated, the designers of the "United States." In March, 1946, the United States Lines commissioned Messrs. Gibbs and Cox to draw up plans for "an outstanding express liner of remarkable safety, speed and efficiency and readily convertible to troop-carrier service." The return to the North Atlantic service of the British luxury liners, in August, 1947, gave rise to further support in American shipping circles for the construction of the liner. Finally, in 1948, a request for federal funds to construct the ship met with congressional approval. All American shipyards capable of building a ship of this size were asked by the U.S. Maritime Commission, in August, 1948, to submit tenders for the construction of the vessel. A lowest tender of 67,350,000 dollars was submitted by the Newport News Shipbuilding and Dry Dock Company in December, 1948. Once details of the financing arrangements between the United States Lines and the Maritime Commission had been agreed upon, the yard was asked to proceed with construction. The keel of the vessel was laid on February 8, 1950, and the liner is said to be now 70 per cent completed. The maiden transatlantic voyage is scheduled to take place in the summer of 1952. The official specification of the "United States" mentions a rated speed of 30 knots, but it is a "widely-circulated secret" that she will be able to exceed this figure. Considerable hopes are being entertained in American shipping circles that the vessel will succeed in obtaining the Blue Ribbon of the Atlantic for the United States.

It is of interest to note that the launching of the "United States" was by "flotation" instead of by the conventional launching procedure. In America there are no inclined ways in existence on which to build a vessel of the size involved, and construction therefore took place in a dry dock. The extensive launching operation began almost fifty-four hours in advance of the official time of the christening of the liner. Progressively, the hull support frames were removed by teams of workmen until the keel blocks were virtually the only support for the vessel. Then, while a final inspection was being made of the bottom of the ship and everything possible was removed from within the dock, mooring lines were made fast between the ship and cleats on the dock wall. The first water entered the dock when valves underneath the bottom of the dock were opened, and approximately forty-five minutes were required to flood the dock to a depth of 21ft. Subsequently, ten gangways linking the ship to the dock were removed and a shipyard crew was placed aboard before the last gangway was taken away. Shortly after 5 a.m. on the day of launching the liner was afloat and completely waterborne for the first time. Once the official christening had taken place, shortly after noon, the liner was pulled out by tugs into the James River and subsequently towed to the fitting-out dock.

Diesel-Electric Shunting Locomotives for Ceylon

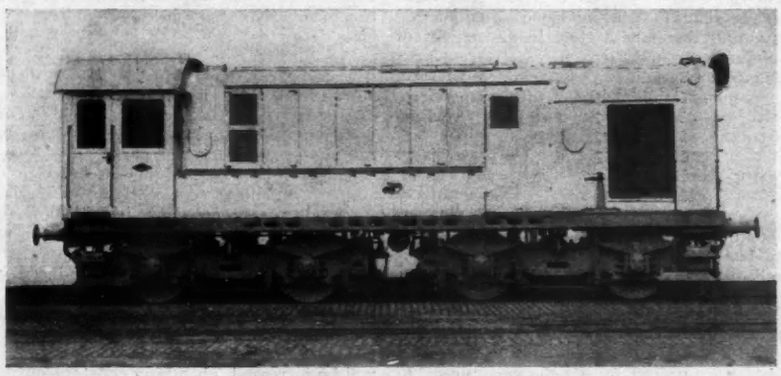
THE photograph we reproduce herewith shows one of eight diesel-electric locomotives built by the North British Locomotive Company, Ltd., of Glasgow, for shunting and freight train haulage on the Ceylon Government Railway. These 5ft 6in gauge locomotives were designed to the requirements of Mr. K. Rampala, the Chief Mechanical Engineer of the Ceylon Government Railway, and the Crown Agents for the Colonies.

The electrical equipment, main and auxiliary generators, traction motors and control gear were designed and supplied by the General Electric Company, Ltd., and each locomotive is powered by a Davey Paxman twelve-cylinder, 625 b.h.p. at 1250 r.p.m. diesel engine.

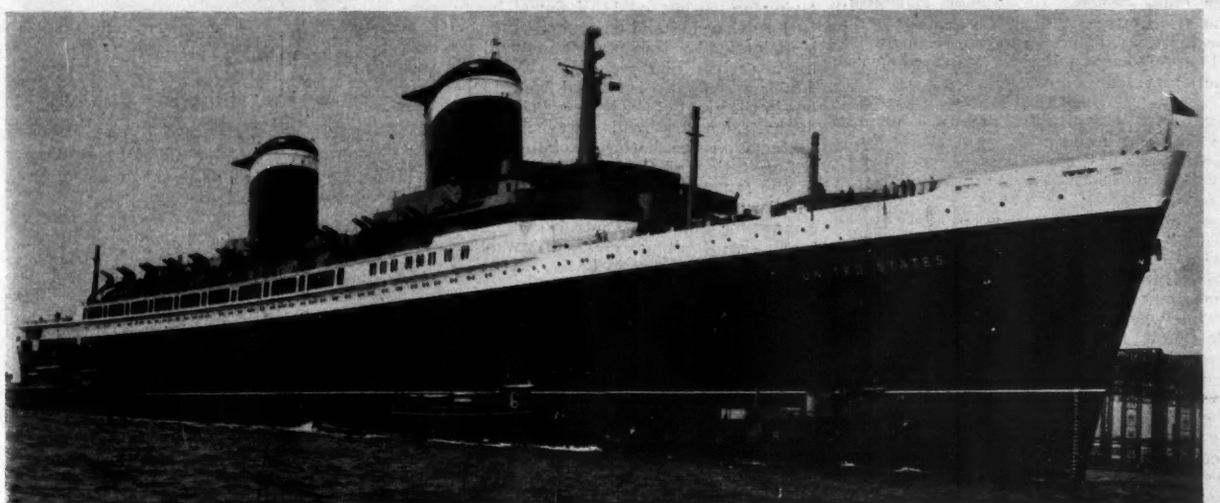
The locomotive is carried on two four-wheel bogies, with a nose-suspended traction motor driving each axle through double-reduction gearing. Its leading dimensions and other particulars are as follows :—

Gauge	5ft 6in
Length over buffers	37ft 9in
Bogie wheelbase	8ft
Total wheelbase	25ft
Wheel diameter	3ft 7in
Weight in working order	54 tons
Tractive effort	35,000 lb
Maximum speed	20 m.p.h.
Reduction gear ratio	17·14 to 1
Fuel oil capacity :	
Main tank	480 gallons
Service tank	70 gallons

The main and bogie frames are welded struc-

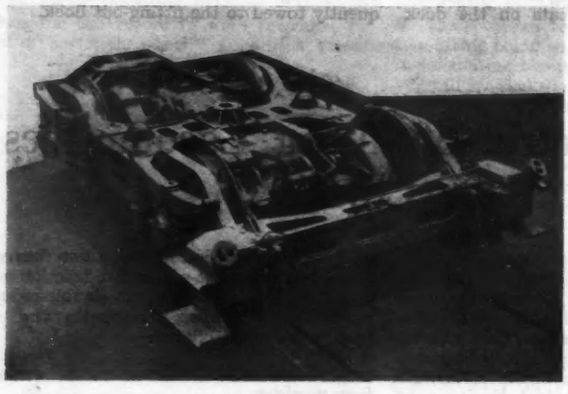


DIESEL-ELECTRIC SHUNTING LOCOMOTIVE



S.S. "UNITED STATES"

tures of steel sections and plates, as light as possible consistent with strength. Side bearers with rubbing faces of manganese steel, each backed by a damping pad of rubber, are mounted on the bogie frames to carry the weight of the body. The spherical seat of each bearer sleeve is supported on a helical spring. Bogie centre pins which carry the traction forces only have spherical collar mountings in the bogie cross stretchers to allow for variations in



BOGIE FOR DIESEL-ELECTRIC LOCOMOTIVE

track aspect. Each double reduction drive from the four traction motors is housed in a single gear case, the intermediate shaft running in bearings in the gear case itself.

The bogie suspension springs, as can be seen in the illustration on this page, are slung above the axleboxes on adjustable links supported by shock-absorbing helical springs. Double-roller bearing S.K.F. axleboxes with grease lubrication are mounted outside the wheels, and manganese steel liners are fitted to the axleboxes and their guides.

Radiators on each side of the superstructure at the forward end have the fan arranged to draw air through the radiators and expel it through the roof of the locomotive. The fan motor is connected across the auxiliary generator so that it runs up with the engine when the power unit is started. It is arranged to run at reduced speed on the first six controller steps and at full speed, by means of a field tap, on the last six steps. These speeds are selected entirely automatically by contacts on the master controller.

One main fuel tank is placed at the front end of the engine compartment and a second at the rear end of the generator compartment, the two being connected by a balancing pipe. A fuel service tank, mounted over the front tank, is supplied while the engine is running by a fuel transfer pump driven by a ¼ h.p. electric motor connected across the auxiliary generator.

The diesel engine and main generator, with an overhung auxiliary generator, are mounted on a light fabricated underbed, supported on the main frame at four points.

The engine, which drives the generators through a Wellman-Bibby flexible coupling, has a bore of 7in and a stroke of 7½in. Twin Brown-Boveri gas superchargers are fitted, producing a normal increase in rating of 25 per cent.

The lubricating system is primed by a "Roloid" oil pump driven by an electric motor of 1½ h.p. In this locomotive the fuel pump control is operated by the lubricating oil pressure, and an increased fuel supply is provided when the priming pump for the lubricating oil is in operation before the engine governor has taken charge. This provides excess fuel at starting. The priming pump motor is stopped automatically and the normal engine lubricating pump takes over well before idling speed. An oil-operated relay prevents the engine being started until the lubricating oil pressure has reached a suitable value, and will stop the engine should the pressure fail.

Engine speed is governed by a centrifugal hydraulic servo-governor driven by bevel gearing from the end of the camshaft. In addition to controlling the fuel supply, the governor is linked to a valve which can admit oil to the servo-motor of the automatic load-control rheostat if the engine speed varies from that selected by the speeder bar. The engine speed is set by pneumatic pistons, operated by electro-pneumatic valves energised through the master controller, which act on the speeder bar. Eight speeds are obtained with only three pistons by means of a special form of linkage between the piston-rods and the speeder bar.

Excitation for the main series winding of the main generator is provided by the auxiliary generator, no separate exciter being employed. In addition, the main generator has a self-excited winding, which assists the separately excited field; a series winding arranged to give a drooping characteristic to the generator output and to limit the maximum current; and a starting winding to enable the generator to be motored for starting the diesel engine.

The locomotives are being delivered with a removable stop fitted on the ninth controller notch, the three remaining notches, giving engine speeds up to 1250 r.p.m., being unnecessary for the class of service on which the locomotives are to be employed at present. Alternatively, stops are being provided so that the controller may be limited to any of the top three steps to suit any service conditions which the locomotives may have to undertake at a later date.

Constant engine loading is obtained through adjustment of the main generator field by an oil-operated rheostat under the control of the engine governor. This control does not operate on the lower notches, where full engine output is not absorbed.

The action of the automatic control is quite simple. Should the diesel engine be overloaded by a change in gradient, it will slow down, causing a change in the governor setting, which operates the rheostat in such a way that the voltage on the main generator is reduced. This in turn reduces the supply voltage to the traction motors and the speed of the locomotive. When the gradient eases and the tractive effort falls off, the locomotive speed will be increased, absorbing constant output.

Auxiliary Services and Braking

The auxiliary generator is a 25kW machine, giving an output of 110V for all auxiliaries, battery charging and control circuits. Voltage is maintained within plus or minus 3 per cent by a carbon pile regulator. Normally the auxiliary generator is excited from the battery, but in the event of the battery being completely discharged and a road start being necessary, contacts on the battery isolator provide for self-excitation of the generator. In addition to the fan motor and oil priming pump, the auxiliary machines comprise a Westinghouse compressor for the control equipment and locomotive braking, and two Westinghouse exhausters for the train brakes.

Discussion on Metal Economics.—The Institute of Metals is arranging a general discussion on the subject of "Metal Economics," which will take place at the Park Lane Hotel, London, W.1, on Wednesday, October 17th. At the morning session consideration will be given to the primary resources of ferrous and non-ferrous metals, and at the afternoon session the discussion will deal with scrap, reclamation, secondary metals and substitute materials. Further particulars of the event can be obtained from the Institute of Metals, 4, Grosvenor Gardens, London, S.W.1.

French Engineering News

(From our French Correspondent)

Electricité de France has recently described the construction of the Aussois hydro-electric scheme in the Savoie. This dam was actually started in 1939, but work was stopped owing to the war. It was restarted in 1946 and was finished only recently because of the peculiar difficulties the construction presented. Situated at an altitude of 2000m it was necessary to install nine "telerific" railways with a total length of 25km. The installation comprises an intake on the Doron de Thermignon River, and a collecting tunnel fed by seven intermediate intakes of tributaries from the Vanoise glaciers, leading to a reservoir holding 3,900,000 cubic metres. There is then a pressure tunnel leading from the reservoir and terminating at a surge shaft, followed by a penstock feeding the power station.

The principal intake includes a dam equipped with a hydraulically controlled 6m by 4·60m sluice gate, controlled either automatically or by hand. A sill with a fine screen permits the flow of the water at a velocity of about 1m per second, and a second weir controls the exact flow. The intermediate intakes all have special arrangements for the removal of solid matter, and flood spilling is ensured by automatic sluices. The average flow of the principal intake is 12 cubic metres per second and that of the intermediate ones about 3 cubic metres per second. The collecting tunnel is 16·5km long and has a section of from 8 to 10 square metres.

The original plan was for two reservoirs with capacities of about 8 to 12 million cubic metres, but Electricité de France, which took the work over from the Société-Hydroelectrique de Savoie, modified the plan, deferring construction of the second reservoir, whilst alternative storage sites are under investigation elsewhere.

The dam itself is in two sections, the inner ends of each section resting on a central abutment; it is faced with stone as a protection against ice.

The production of the scheme will be about 320 million kWh per year, and its installed capacity 90MW, with three horizontal-axis sets with 41,000 h.p. Pelton turbines turning at 600 r.p.m.; the flow is 4 cubic metres per second and the maximum gross head is 2800ft. The plant will be tied into the 150kV network by three 30MVA transformers, but a substantial proportion of the power will be consumed by the aerodynamic wind tunnel of Modane-Avrieux, with which the Aussois scheme is associated (see THE ENGINEER, March 2nd, 1951).

* * *

The launching of the "Bretagne" (19,000 tons) and the "Ferdinand de Lesseps" recently took place. Before the end of the year the "Flandre" (20,419) will be launched as well as five or six other ships of about the same tonnage. At the moment there are nineteen packets under construction or going through their trials. This activity will bring French tonnage up to 20·7 per cent of the world's total.

* * *

French Railways have reported on new material and rolling stock delivered in 1950. The report states that during the year about 25,000 million francs were spent on material and rolling stock, which included 32 steam locomotives, 91 tenders, 74 electric locomotives, 67 "autorail" cars, 13 diesel locomotives, 35 shunting engines, 148 passenger coaches, and 9550 trucks of various kinds. Repairs and reconstruction work amounted to just over 1000 million francs.

* * *

In a note in this column in our issue of August 3rd it was stated that Renault Regie had ordered diesel motors for its new tractors to the value of £300,000 from F. Perkins, Ltd., of Peterborough, and that the motors were to be constructed in France under British licence. We are now informed by F. Perkins, Ltd., that the latter part of that statement is incorrect. The engines will, in fact, be supplied as complete units by the Perkins factory at Peterborough and installed in the tractors by the Renault Company in France.

Industrial and Labour Notes

Iron and Steel Price Increases

The Iron and Steel Prices (No. 2) Order, 1951, which has been made by the Minister of Supply and which came into force on Monday last, August 13th, authorises increases of from approximately 10 per cent to 25 per cent in the controlled maximum prices of iron and steel. The last general increase in iron and steel prices was made in April, 1949.

The Ministry of Supply has stated that the present increases are necessary because of a sharp rise in the prices of imported iron ore, scrap, pig iron and semi-manufactured steel, and because of recent increases in costs in this country, including increases in wages, transport, scrap and fuel costs. In March last, the Ministry says, it was informed by the British Iron and Steel Federation that, in view of the serious cost increases, early consideration needed to be given to the position. The prices now authorised are based on recommendations put forward by the Iron and Steel Corporation of Great Britain, after consultation with the British Iron and Steel Federation and, it is claimed, take account of the savings in capital charges secured by nationalisation.

Hitherto the loss arising from buying finished steel abroad and selling it in this country at home prices has been borne by the Exchequer. With the rise in world prices this loss has risen steeply and the Government has now decided that to avoid increasing the subsidy, the trading loss—but not the import duty—should be recovered by an adjustment spread over home controlled prices. This, the Ministry indicates, accounts for over 20 per cent, and other imported steel and steel-making materials for about 40 per cent of the overall price increases. Some examples of the increases are as follows, the new basis prices per ton being given in parentheses: foundry pig iron, 11s. 6d. (£11 4s. 6d.); basic pig iron, 16s. 6d. (£11 15s. 6d.); soft basic billets, £4 7s. 6d. (£21 16s. 6d.); joists, £3 10s. 6d. (£24 2s.); re-rolled bars, £4 16s. (£27 11s.); uncoated sheets, £6 2s. 6d. (£35 15s. 6d.); tinplate (per basis box), 6s. 11d. (£2 9s. 6½d.).

The new Order, which gives full details of the revised prices, can be obtained from H.M. Stationery Office, Kingsway, London, W.C.2, price 4d. The relevant deposited schedules may be seen at regional offices of the Ministry of Supply and at Steel House, Tothill Street, London, S.W.1.

One immediate effect of the new prices is an increase in the prices of nuts and bolts. The price changes in this case are authorised by the Bolts, Nuts, &c., Prices (No. 2) Order, 1951, which can also be obtained from H.M. Stationery Office, price 3d.

Iron and Steel Production

The iron and steel production figures for July, issued by the British Iron and Steel Federation at the end of last week, reflect not only the effect of the holiday season, but also the shortage of steel-making materials. July output of steel ingots and castings averaged 256,100 tons a week, which was comparable with an annual production rate of 13,317,000 tons. The annual rate of production achieved in July last year was 14,367,000 tons. In June this year production was at an annual rate of 16,007,000 tons.

Pig iron production in July was better than that of the corresponding month last year. It averaged 182,400 tons a week, thus showing an annual rate of 9,484,000 tons. The annual rate during June was 9,497,000 tons and in July last year 9,099,000 tons.

Iron and Steel Scrap

The steel committee of the United Nations Economic Commission for Europe has recently approved a report submitted by the panel constituted to examine the ferrous scrap situation in Europe. The last general report by the panel was made in September, 1949, when it was noted that the European countries had regained "the possibility to cover their scrap requirements either from their own home sources or from imports."

The present report says that, until about the end of the third quarter of 1950, scrap supplies had been adequate in Europe, although there were some indications of an "unbalance"—which became more acute at the beginning of this year—chiefly for the following reasons: the sharply increased demand for steel calling for maximum utilisation of production capacity and the failure of pig iron production to reach original targets; the considerable reduction in scrap exports, mainly from Western Germany, resulting from diminishing availabilities of easily recoverable war scrap, and the raising of the authorised steel output in that country; the resumption of scrap imports from Europe by the U.S.A. and other American countries; delay by certain countries, in view of the changed circumstances, in taking adequate measures to maximise the collection and the flow of scrap to the consuming works, which did not enable them to ensure, at the same time, supplies for their own industry and "disorderly demands" from buyers for importing countries.

The report goes on to say that, although scrap by itself cannot always provide a solution to the steel industry's raw material problem, steel-makers in some countries at the present time are not able to work to maximum capacity unless they obtain increased supplies of scrap without delay. The panel's opinion is that all the European countries, despite measures already taken and results achieved, must do still more to improve scrap supplies. The measures recommended by the panel include the suggestion that each country's scrap price policy must be such as to encourage the collection of all available supplies, including the marginal tonnages, which are difficult and expensive to collect and which might not normally be recovered. In certain cases, the report says, the price policy might include special subsidy arrangements. Another suggestion put forward relates to publicity. The panel's view is that intensive, organised collection and appeals to holders of scrap can have a favourable influence on the amount collected. But, the report observes, even where high prices constitute an incentive for maximum collection, there is always some scrap which is not drawn out. This, the panel thinks, is because the owners of even small quantities of scrap are not aware of the immediate benefit they can derive from selling their scrap, or because those who are in immediate control of the scrap are not personally interested in the price factor. Finally, the panel advocates stock control, saying that however unpopular it might be, the effective limitation of the level of scrap stocks held by suppliers and the control of stocks at consumers' works, would prevent unhealthy speculation and ensure more regular deliveries and distribution.

G.P.O. Engineering Staff's Pay Increases

Pay increases for nearly 60,000 members of the engineering, supplies and motor transport grades of the Post Office engineering department have been notified to the Post Office Engineering Union by the Civil Service Arbitration Tribunal. The award follows a claim by the union, which was heard by the tribunal on July 23rd.

Under the terms of the award, technical officers will receive increases ranging from 9s. a week at the age of twenty-one to 13s. on the maximum, thus bringing their maximum weekly rate to £8 18s. in London and £8 11s. in the provinces. The varying grades of technicians will receive increases ranging from 9s. to 12s. 6d. a week. For labourers, the increase is to be 8s. a week, giving a weekly wage, after one year's service, of £5 12s. in London and £5 8s. in the provinces. In the supply grades the increases awarded range from 8s. to 10s. 6d. a week, and in the motor transport grades the increases are from 8s. to 12s. a week.

The union has stated this week that, broadly speaking, the award represents an average increase of 10s. a week, compared with an average of 5s. a week offered by the G.P.O., and an average of about 25s. a week claimed by the union. By the union, the award has been described as "extremely disappointing."

National Insurance Contributions

The Ministry of National Insurance has drawn attention to the increased rate of contributions, provided for in the National Insurance Act, 1946, which will operate from October 1st next. In the employed persons' class the increase amounts to 4d. a week for men and women over eighteen, and 2d. a week in the case of boys and girls under that age, the increases being equally divided between employers and employees. The new weekly rates will thus be as follows:—Men, 5s. 1d. (paid by employee), 4s. 4d. (paid by employer), total 9s. 5d.; boys, 2s. 11½d. (employee), 2s. 6½d. (employer), total 5s. 6d.; women, 4s. (employee), 3s. 5d. (employer), total 7s. 5d.; girls, 2s. 5d. (employee), 2s. (employer), total 4s. 5d. There are to be corresponding increases in the contributions of self-employed and non-employed persons.

Confederation of Shipbuilding and Engineering Unions

The annual conference of the Confederation of Shipbuilding and Engineering Unions is being held this week in Swansea. It began on Tuesday last, when Mr. H. G. Brotherton delivered his presidential address.

In the course of that address Mr. Brotherton referred to the rapid rise in prices and said that the small advance in wage standards obtained last year, through the efforts of the Confederation, was quickly absorbed. He thought that during the last few months there had been a very real worsening of living standards. He went on to say that the relationship between profits, wages and the cost of living was one which the unions could not allow to continue. Shipbuilding and engineering workers had made a significant contribution to the increased output of the industries, but, Mr. Brotherton declared, they had not made that contribution so that profits should soar to new heights. Irrespective of the nature of the Government of the day, he added, it was the task of the trade union movement to protect and advance the interests, and above all the economic interests, of its members. That was a responsibility which could never be abdicated.

At the time of going to press with these notes the conference was discussing wages in the shipbuilding and engineering industries. Consideration was being given to a proposal that a claim should be made for an all-round wage increase of £1 for a forty-four-hour week, with the maintenance of merit and craft rates and district differentials.

The Coal Situation

Coal output in Great Britain is at present affected by the annual holidays, and last week's production from the deep mines, 2,457,700 tons, was the lowest recorded this year. Output from opencast workings amounted to 142,300 tons, giving a total production for last week of 2,600,000 tons, compared with 2,884,800 tons in the preceding week and 2,611,000 tons in the week ended August 12, 1950. The Ministry of Fuel and Power says that last week's mined output included 81,400 tons raised by Saturday work in 192 pits.

In the week ended August 4th distributed coal stocks increased from 13,765,000 tons to 13,876,000 tons. In that week, however, the number of wage earners on colliery books declined by 300 to 700,100. Of that number there were 288,100 at work at the coal face.

Notes and Memoranda

Air and Water

FLOATING DOCK TOW.—One of the largest floating docks in the world has arrived at Falmouth from Hamilton, Bermuda, where it has been used by the Royal Navy for servicing large fleet units. The tow commenced on July 12th and was carried out by the three naval tugs "Reward," "Warden," and "Prosperous."

VOYAGE BY HALF-TANKER.—The aft end of the 29,000-ton Norwegian tanker "Rendefjell" has been towed from the yard of John Crown and Sons, Ltd., Sunderland, to the Tyne for the installation of engines. The fore end of the vessel, which is being built in two sections, will be launched next month and the two halves joined in dry dock.

THE ROLLS-ROYCE "AVON" ENGINE.—It has been announced that the Standard Motor Company, Ltd., is to undertake the manufacture, assembly and testing of the "Avon" jet turbine. This unit has been chosen for the leading fighter and bomber aircraft, now stated to be in quantity production. These machines include both the high-speed day interceptor fighters, the Vickers Supermarine "Swift" and the Hawker "P1067." Bombing aircraft, fitted with this engine, are the "Canberra" and the four-engined "Valiant" machine.

THE "AVRO 707B."—A. V. Roe and Co., Ltd., recently arranged a flight demonstration of its "Delta" wing machine at Dunsfold Aerodrome, Guildford. It was stated that the low-speed characteristics of this version of the "707" aircraft were more favourable than was usual with conventional jet fighters. This company regards its "Delta" wing machines not as prototype jet fighters, but as scale models of what it envisages as future high-speed transport aircraft. The general flying characteristics of both versions of this aircraft are stated by the builders to have exceeded expectations.

Miscellanea

BUILDING PLASTERS.—The Minister of Works has made an Order providing for an increase of 4s. per ton in the maximum prices of building plasters, with effect from August 7th. This increase is wholly due to the increased cost of paper bags.

ROYAL SHOW, 1952.—The council of the Royal Agricultural Society of England has approved preliminary plans for the lay-out of the 1952 Royal Show, which is to be held at Stover Park, Newton Abbot, next July. It is stated that the area of the show ground will be about 25 per cent less than the site at Cambridge, on which this year's show was staged.

NORTHERN IRELAND TRADE.—Northern Ireland's Ministry of Commerce has reported that the value of the country's exports in 1950 was £183,024,000, compared with £163,851,000 in 1949 and £156,937,000 in 1948. The value of ships and aircraft built and repair work done last year for owners outside Northern Ireland amounted to £31,218,000.

ENGINEERING, MARINE AND WELDING EXHIBITION.—The Engineering, Marine and Welding Exhibition, with which is incorporated the Foundry Trades' Exhibition, will open at Olympia, London, on Thursday, August 30th. It will continue until Thursday, September 13th, and will be open each weekday from 10 a.m. till 8 p.m. As usual, the exhibition is being organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, W.C.2.

TOWLER BROTHERS (PATENTS), LTD.—We are informed by Towler Brothers (Patents), Ltd., of Rodley, near Leeds, that it will not be able to show its products at the forthcoming Engineering and Marine Exhibition at Olympia, as all the equipment it was proposed to exhibit was destroyed in a fire at Hull Docks on July 13th. The space allocated at Olympia to the firm will be made available for use as a public lounge during the period of the exhibition.

BRITISH STANDARDS YEAR BOOK.—The British Standards Institution has published a new edition of its year book. More than half of its 400 pages are devoted to a list of the 1700 British Standards current at December 31, 1950, with a brief description of the subject-matter and scope of each one. A complete subject index simplifies reference. In addition, a supplement listing the British Standards issued between January 1 and March 31, 1951, is included. The year book also gives the current membership of the general council, which guides the Institution's general policy; of the four Divisional Councils (Building, Chemical, Engineering and Textile), which direct the standardisation work; and of the fifty-six industry standards committees, each representing a major British industry, and through which that work is delegated to some 2000 technical committees and sub-committees, whose members bring specialist technical and commercial knowledge to bear upon every standardisation project dealt with. Copies of the year book may be obtained from the British Standards Institution, Sales Department, 24, Victoria Street, London, S.W.1, price 7s. 6d. each, post free.

SELF-ETCH PRIMER.—A self-etch primer which serves the purpose of etching the surface of non-ferrous metals, is now being manufactured by Arthur Holden and Sons, Ltd., Bordesley Green Road, Birmingham, 9. Holdenite S.E.P. performs the dual function of eliminating the passivating process essential in the preparation of aluminium and its alloys and of providing a primer coat. The primer is ready mixed and after thinning has a can life of many weeks, will dry in fifteen minutes, and take a coating of cellulose lacquer and stoving or air drying enamels.

INSTITUTION OF WORKS MANAGERS.—The Institution of Works Managers has recently established three new branches at Northampton, Preston and Wolverhampton, thus bringing the number of its branches to fifteen, twelve of them having been formed in the past four years. The Institution also announces its intention to invite not more than fifteen of its members, each year, who are "men of distinction in the practice of works management" to become Fellows. The first fifteen Fellows, invited during the current year, have just been elected.

TRANSMISSION LINES FROM BOAT OF GARTEN TO ABERDEEN.—The Secretary of State for Scotland has confirmed a scheme for the erection of overhead transmission lines from Boat of Garten in Inverness-shire to the transforming station at Craigiebuckler in Aberdeen, at an estimated cost of £698,600. The North of Scotland Hydro-Electric Board has given an assurance that the lines will avoid woodlands and plantable land as far as possible; that cutting will be kept to a minimum, and that, where practicable, towers will be kept below the skyline. A White Paper on the scheme is available from H.M. Stationery Office, 13A, Castle Street, Edinburgh, or through any bookseller.

INTERNAL COMBUSTION ENGINE RESEARCH ASSOCIATION.—At the recent annual general meeting of the British Internal Combustion Engine Research Association, the Viscount Falmouth, M.I.Mech.E., Companion I.E.E., was re-elected president of the Association for 1951–52. Air Commodore F. R. Banks, C.B., Dr. S. F. Dorey, C.B.E., F.R.S., Sir Lynden Macassey, K.B.E., K.C., Vice-Admiral (E) The Hon. D. C. Maxwell, C.B., C.B.E., and Lieut.-General Sir Frederick G. Wrisberg, K.B.E., were re-elected vice-presidents. The Director-General, Fighting Vehicles Division, Ministry of Supply, Major-General H. E. Pyman, C.B., C.B.E., D.S.O., was also elected a vice-president. Mr. H. B. V. Teague, of Crossley Brothers, Ltd., has succeeded Mr. J. Jones as chairman of the council.

APPRENTICE TRAINING SCHEME.—A revised craft apprenticeship training scheme to be adopted by the South-Western Electricity Board will give boys an opportunity of learning something of the Board's organisation as a whole and of the wider ramifications of the industry. For their first eighteen months boys will spend short periods in various departments to gain a wide knowledge of the Board's activities, after which they will receive specialist trade training for about three and a half years. The range open to them includes trades dealing with mains, wiring, meters, transport, workshops, drawing-office and building. The scheme is open to boys of fifteen or sixteen years of age, and time and financial assistance will also be given to boys to attend their local technical college or school for approved courses. Apprentices will be given special facilities for film lectures, and it is hoped to arrange visits to power stations. Any apprentice considered suitable may be promoted at the end of the first eighteen months' training to the student apprenticeship scheme leading to appointments on the technical staff.

IMPORT OF TUNGSTEN ORES.—As already announced, the Ministry of Materials became the importer of tungsten ores and concentrates, with effect from July 30. Import licences for private import of tungsten ores are now not normally issued, but imports continue to be allowed under licences already issued. The import and distribution of tungsten ore will be conducted in future through agents drawn from the trade, and for this purpose it is proposed to form a company whose management will include representatives of the following three firms:—Derby and Co., Ltd., 62–63, Cheapside, London, E.C.2; Metal Traders, Ltd., 7, Gracechurch Street, London, E.C.3, and H. A. Watson and Co., Ltd., 115, Old Broad Street, London, E.C.2. Pending the formation of the company, offers of tungsten ore may be made to any of these three firms, who will make bids on behalf of the Ministry. For material procured abroad by other United Kingdom merchants the bid will take account of their expenses. Consumers of tungsten ore are being approached individually about their requirements, but, until the new arrangements can be brought fully into effect, consumers with urgent requirements should communicate with the Ministry of Materials, Branch 4.c (2), telephone, Trafalgar 8888, Extension 7561. The price of concentrates of standard 65 per cent grade and ordinary quality will be £26 15s. per long ton, delivered consumer. This price will be reviewed at the end of the quarter, but no change is contemplated before then.

Personal and Business

MR. D. L. H. WILLIAMS has been appointed chief engineer and a director of Westland Aircraft, Ltd.

MR. S. L. FINCH, M.I. and S.I., has been appointed a director of Catton and Co., Ltd., Yorkshire Steel Foundry, Leeds.

KEITH AND BOYLE (Ldn.), Ltd., has changed its address to Terminal House, 80, Clapham Road, London, S.W.9 (telephone, Reliance 4211).

LESLIE TURNER AND PARTNERS, consulting engineers, announce the removal of their offices to 6, Grove Road, Sutton, Surrey (telephone, Vigilant 0042).

MR. HOWARD THOMPSON, chairman and managing director of Thompson Bros. (Bilston), Ltd., has assumed office as president of the Institute of Welding.

DR. W. G. RADLEY, deputy engineer-in-chief, General Post Office, is to succeed Sir Archibald Gill as engineer-in-chief on the latter's retirement on October 1st.

B. O. MORRIS, Ltd., Clay Lane, Coventry, states that it has been appointed sole agent in the United Kingdom and Australia for automatic polishing machines manufactured by E.R.M.A., of Paris.

MR. W. R. HEROD has tendered his resignation from the board of Associated Electrical Industries, Ltd., in view of his appointment as co-ordinator of the North Atlantic defence programme.

THE MINISTRY OF SUPPLY states that Commander (E) Frederick W. Hornsby, R.N. (ret.), M.I. Mech.E., A.M.I.C.E., has been appointed to the newly-created position of Director of Standardisation (Defence).

MR. C. G. GUTHRIE, who has been for the past seventeen years superintendent engineer of the Lamport and Holt Line, Ltd., and has also acted in this capacity, in recent years, for the Booth Steamship Company, Ltd., is retiring next month.

MR. J. JONES, who has been chief engineer of the National Gas and Oil Engine Company, Ltd., since 1939, and general manager since 1949, retired in July this year after forty-three years' service, and has been succeeded by Mr. J. Smith, the assistant chief engineer to the company.

THE BRITISH BROADCASTING CORPORATION announces the following appointments:—Mr. G. Stannard, A.M.I.E.E., assistant superintendent engineer (lines), in succession to Mr. W. G. Edwards, who has retired; Mr. R. C. Patrick, A.I.E.E., assistant superintendent engineer (recording).

GEORGE COHEN, SONS AND CO., Ltd., announces that Mr. J. A. J. Blanckensee and Miss E. P. Wood, joint general managers of its raw materials division, have been elected to the boards of Pollock Brown and Co., Ltd., Westbourne Park Coal and Iron Company, Ltd., and Southall and Hayes Coal and Iron Company, Ltd.

THE BRITISH PLASTICS FEDERATION has established a panel of publicity experts under the chairmanship of Mr. W. M. York, of E. K. Cole, Ltd. Any inquiries relating to the plastics industry of this country should be sent to the general manager of the Federation, 47–48, Piccadilly, London, W.1 (telephone, Regent 4681).

Contracts

HENRY ROBB, Ltd., has contracted to build, for the Sarawak Steamship Company, Ltd., a twin-screw motor passenger and cargo ship of 1150 tons deadweight for shallow-draught work between the smaller ports in Sarawak and Singapore. The ship will have a length between perpendiculars of 212ft by 44ft breadth moulded and will be propelled at 10 knots by two sets of Ruston and Hornsby geared diesel engines, each of 504 b.h.p. at 500 r.p.m.

British Patent Specifications

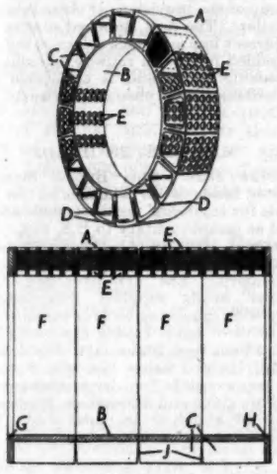
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

HEAT EXCHANGERS

655,313. December 12, 1947.—Regenerative Heat Exchangers for Combustion Turbines, The Minister of Supply, of Adelphi, Strand, London, W.C.2; C. A. Parsons and Co., Ltd., Heaton Works, Newcastle on Tyne, 6; and Andrew Thompson Bowden, 14, Wellburn Park, Jesmond, Newcastle on Tyne (*Inventors: Andrew Thompson Bowden and Paul Kolb*).

This invention relates to combustion turbines of all types in which the working fluid may be obtained from a solid, liquid or gaseous source, for instance, gas, oil or coal, and which may be produced either internally or externally. Referring to the drawing, the outer and inner shells *A* and *B* are connected by the radial ribs *C*, which have slots *D* cut in them to a depth which allows



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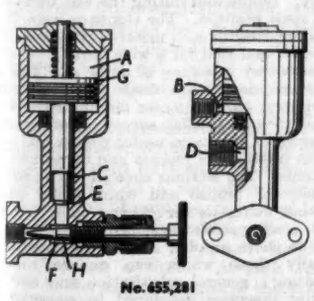
free expansion of the outer shell relative to the inner shell. The outer and inner shells have holes or slots *E*, through which the hot gases and the air may pass so as to traverse the matrix. In general the drum is sub-divided in its axial direction into a number of sectional drums, connected together. The lower view shows a form of construction employing a complete drum made up of elements. It is composed of four similar elements *F*, secured between end plates *G* and *H*. The sections are secured to the end plates by longitudinal bolts. The sections of the composite drum are manufactured in such a way as to leave a gap *J*, which tends to close up as the temperature of the outside wall of the drum reaches the operating temperature of the unit.—*July* 18, 1951.

VALVES

655,281. June 21, 1948.—Fuel Supply Valves, Christopher Shorrock, Moorlands, Garstang Road, Preston.

As shown in the drawings, a main cylinder *A* is formed in the upper enlarged part of the upright of the casting and a port *B* communicates with the discharge of a fuel atomising compressor. Formed in the lower and narrower part of the upright of the



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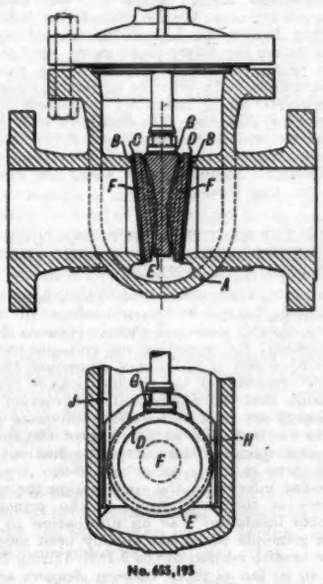
casting and concentric with the cylinder is a combined piston body and guide cylinder *C*. A port *D* for the inlet of fuel is located approximately midway between the ends of this guide cylinder. The lower end of the guide cylinder has an annular coned valve seating *E*. The centre of the valve opening thus formed communicates with a chamber *F* in a transverse bore formed in the length of the cross piece of the casting. A valve-operating piston *G* in the main cylinder has a compression spring arranged between its top and the cylinder cover to keep the piston in its lower or valve-closing position. The transverse bore along the length of cross piece of the casting is fitted with a fine adjustment needle valve *H*. In operation the needle valve is set to give the desired rate of flow of fuel and pressure built up by the compressor moves the valve operating piston against the pressure of the compression spring. The seating valve is thus opened and on further upward movement of the piston the oil inlet port *D* is opened as the narrower part of the guide rod comes opposite to it. Fuel will continue to flow through the inlet port, seating valve and needle valve until the compressor is stopped. When the compressor is stopped the compression spring takes charge and moves the piston back to its closing position. This movement of the piston causes the guide rod first to close the fuel inlet port, then the seating valve. The fit of the guide rod against the inlet port relieves the seating valve of practically all pressure and ensures a clean cut-off of the fuel supply.—*July* 18, 1951.

655,195. April 7, 1948.—Sluice or Gate Valves, G. Dikkers and Co., N.V., 15, Industriestraat, Hengelo (O), The Netherlands.

As illustrated in the upper drawing the casing *A* is provided with hard metal seat rings *B* welded to the casing and co-operating with the slide *C*, which has corresponding welded sealing faces *D*. The slide comprises a rigid central part *E* with two truncated conical flanges *F* carrying the sealing faces. The operating spindle of the slide terminates in a collar *G* engaging below a hook-shaped projection provided on the central part of the slide. This



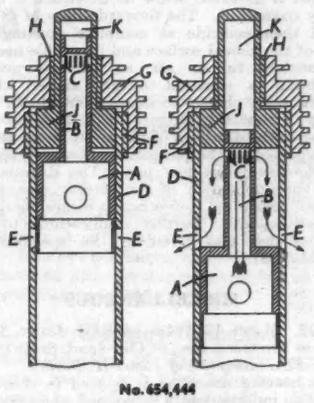
No. 655,195

part of the slide *E* is further provided with two lateral grooves *H* by means of which the slide with a certain clearance is guided on ribs *J* projecting from the inner wall of the casing. Since the flexible flanges *F* are connected to the central part *E* on a relatively small sectional area suitable deflection of the flange is secured only in the centre of the slide, the deflection being greatest at the marginal portions and smallest near the centre. Although the flanges are made of metal they have a certain degree of flexibility. For a 6in valve the deflection at the marginal portions of the flanges is less than one-sixty-fourth of an inch. This deflection corresponds to the maximum deformation of the seats in the casing due to the transmission of heat by the fluid to the casing of the valve. With the slide according to the invention, therefore, sticking at variations of temperature is avoided. Modifications in the design are also indicated in the specification.—*July* 11, 1951.

INTERNAL COMBUSTION ENGINES

654,444. May 7, 1948.—Two-Stroke Compression Ignition Engines, John Robertson Brown, of 111, Eastcote Road, Pinner, Middlesex.

This invention relates to two-stroke compression ignited internal combustion engines, particularly to that type of engine in which compression created in the crankcase by the down stroke of the piston is employed to feed the explosive mixture into the combustion chamber. Referring to the drawings, the piston *A* is formed with a central tubular extension *B* to its top. Near the top end of the extension an inlet port *C* is formed by a number of fine vertical slots or small lateral bores. The cylinder *D* has exhaust ports *E*



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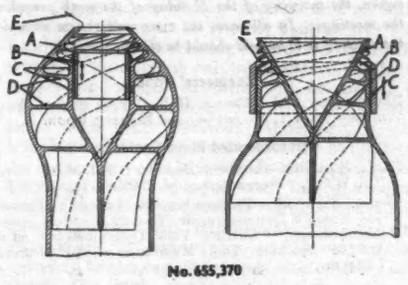
and is externally threaded at *F* to carry a cooling head *G*. A contra-piston *J* has a central bored portion *K*, which is externally threaded to enter and engage with the aperture *H* in the cylinder cooling head. The extension *B* of the piston works in this portion of the contra-piston so that the inlet port *C* is closed by it against crankcase suction or pressure, as shown in the left-hand view, except when the piston is at the bottom of its stroke, as shown in the right-hand view. Combustion gases compressed in the crankcase due to the downward movement of the piston pass through the piston and its extension to enter the top of the combustion chamber, whilst the burnt gases are exhausted at the bottom through the outlet ports in the cylinder wall, as shown by the arrows in the right-hand view. The specification shows various modifications in the design.—*June* 20, 1951.

HYDRAULIC MACHINERY

655,370. December 31, 1947.—Means for Guiding the Flow of Fluid, Arthur Abbey, 111/112, Hatton Garden, London, E.C.1 (*communicated by the Société Financiere d'Expansion Commerciale et Industrielle, S.A., "Sfindex," Sarnen, Switzerland*).

This invention relates to a guiding means for liquids and gases or for mixtures carrying particles of matter. The requirements which the guiding means in certain plant must meet must be such as to guide a gas or liquid with a definite tangential component along a solid of revolution. They must in addition produce a uniform flow with full admission about the entire circumference, and if necessary convert potential energy into kinetic energy and vice versa. In addition, it must be possible to vary the admission and the area of through-flow while maintaining the angle of flow constant, and in certain cases it must be possible to vary at will the tangential component of the flow. The regulation of the area of an annular flow with full admission over the entire circumference is obtained in accordance with the invention



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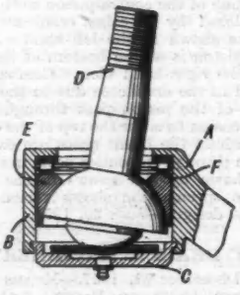
owing to the fact that a spiral flow-guiding surface, having at least a single thread, is situated within two surfaces of revolution limiting an annular flow, and that at least annular parts of one flow-limiting surface of revolution are displaceable in the axial direction in order to adjust the area of through-flow whilst maintaining the angles of flow constant. The drawings show constructional examples of annular nozzles or diffusers in vertical centre section. *A*, *B* and *C* represent the flow-limiting surfaces in section, the area of through

flow being varied by the position of *B* in the direction of the double arrow. *D* is a single or multi-threaded spiral surface determining the direction of flow and in particular the rotational component. It is to be considered as geometrically formed from a spiral movement of a line, which may be a straight line passing through the axis. According to the requirements, it is possible also to make only the part *B* movable, while its extension *C* may be rigidly connected. The forward edges of *B* and *C* would then coincide at complete opening. The pitch of the helical surface and its profile need only be constant in so far as this is necessary to obtain a constant outlet angle, while it can gradually change to infinity outside *B*, that is to say within the range of *C*. The flow freely leaving in the direction of the arrow *E* has the form of a hyperboloid, the generatrices of which constitute the rectilinear out-flow jets. The drawings also show the application of the guiding means as an annular nozzle for converting pressure energy into velocity energy. Further applications to water turbines are also given in the specification.—*July* 18, 1951.

MISCELLANEOUS

655,092. March 13, 1948.—A Ball Joint, Thompson Products, Inc., of Cleveland, State of Ohio, U.S.A. (*assignees of James H. Booth*).

The bearing described is housed in the control arm of an independently suspended wheel structure. The arm *A* has an inverted end portion *B* forming a chamber with an opening at the upper end. The lower open end of the chamber is closed by a plate *C*. A ball stud *D* projects through the opening and



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tilting movement of the stud away from the central longitudinal axis of the joint relative to the housing portion *B* is provided for by a thrust ring or collar *E*. Free rotation of the stud is provided by a roller bearing assembly *F*. The various elements of the ball joint are held together in the chamber by a spring washer, which is compressed between the closure plate and a spring seat member which has a socket portion adapted to receive the spherical lower end of the stud.—*July* 11, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

Engineers' Guild

Thurs., Sept. 27th.—Caxton Hall, Caxton Street, Westminster, S.W.1, Annual General Meeting, 6 p.m.

Incorporated Plant Engineers

Tues., Sept. 4th.—London Branch: E.L.M.A., Savoy Hill, W.C.2, "Storekeeping," J. Barrett, 7 p.m.

Thurs., Sept. 6th.—Peterborough Branch: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, "Cutting Tool Dynamometry as an Aid to Machine Tool Maintenance," J. Purcell, 7.30 p.m.

Institute of Road Transport Engineers

Tues., Aug. 28th.—Visit to the works of Vauxhall Motors, Ltd., Luton, Beds, 10.15 a.m.

Institution of Works Managers

Tues., Sept. 4th.—Wolverhampton Branch: Works Visit to Goodyear Tyre and Rubber Company, Ltd., Wolverhampton, and John Thompson (Wolverhampton), Ltd.

Royal Aeronautical Society

Mon., Sept. 10th.—Royal Institution, 21, Albemarle Street, W.1, 39th Wilbur Wright Memorial Lecture, "The Well-Tempered Aircraft," A. E. Raymond, Douglas Aircraft Corporation, 6 p.m.

Thurs., Oct. 4th.—Institution of Civil Engineers, Great George Street, S.W.1, Seventh British Commonwealth and Empire Lecture, "Air Transport in New Zealand and the South Pacific," Air Vice-Marshal Sir L. M. Isitt, R.N.Z.A.F., 6 p.m.

Stephenson Locomotive Society

Sat., Aug. 18th.—Visits to Motive Power Depots (London and Southern), Stratford, (North Eastern) Gateshead, (North Western) Bolton and Bury, (Scottish) St. Margarets, 2.30 p.m.

Sun., Aug. 19th.—Visit to Swindon Locomotive Works and Running Sheds, from 1.30 p.m.

Sat., Aug. 25th.—Lineside Traffic Observation, Bromsgrove and Lickey Incline, L.M. and W. Regions, from 2 p.m.

Sat., Sept. 1st.—Scottish Centres: Tour by special train over routes not usually available for passengers, Paisley—Johnstone—Barrhead. Start Paisley (East Mineral) about 2.45 p.m.

Sat. Sept. 8th to Sun. Sept. 9th.—Week-end tour of Motive Power Depots in Swansea and South Wales area.

Sat., Sept. 15th.—Visit to Ashford Locomotive Works and Running Shed, S.R., from 2.45 p.m.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

FILLING RATIOS FOR LIQUEFIABLE GASES

No. 1736 : 1951. Recommendations made in the Fourth Report of the Gas Cylinders Research Committee of the Department of Scientific and Industrial Research (1929) were adopted in B.S. 401, "Steel Cylinders for the Storage and Transport of Liquefiable Gases." That standard included a table, reproduced from the same source, giving recommended filling ratios for ten liquefiable gases. The new British Standard, B.S. 1736, "Filling Ratios for Liquefiable Gases," specifies filling ratios for thirty-three gases, two ethylene oxide mixtures and hydrocarbon gas mixtures. In accordance with practice in this country there are separate filling ratios for temperate climates and tropical climates. The document also includes definitions which are necessary for a complete understanding of the Standard as well as general requirements regarding the filling of cylinders. Price 2s., post free.

DOMESTIC ELECTRIC KETTLES, DOMESTIC ELECTRIC IRONS, DOMESTIC ELECTRIC VACUUM CLEANERS

Nos. 1671, 1732, 1645 : 1951. These three recently published British Standards relate to electric kettles, electric irons and electric vacuum cleaners, respectively, for operation on voltages exceeding 30V a.c. or 50V d.c., but not exceeding 250V a.c. or d.c. The aim of the specifications is primarily to ensure that the design and construction of the appliances are such as to afford adequate protection to the user, and in this respect the specifications correspond to the safety specifications which are in force in many other countries. A point of particular interest in the specification for vacuum cleaners is the recognition of the principle of "double insulation" as an alternative to earthing, a principle which has already been recognised in the twelfth edition of the I.E.E. Wiring Regulations in so far as these vacuum cleaners are concerned. Price 2s. each, post free.

WEIGHTS OF SPECIAL CASTINGS (P.D. 1166 : 1951)

No. 78 : 1938 (Addendum No. 1). The recently published Addendum No. 1 to B.S. 78—"Cast Iron Pipes (Vertically Cast) for Water, Gas and Sewage"—sets out the weights of special castings dealt with in that standard which was last revised in 1938. At the time of preparation of the revision the weights of special castings had not been calculated, but it was felt undesirable to withhold publication on that account. Price 3s. post free.

BRITISH ASSOCIATION (B.A.) SCREW THREADS

No. 93 : 1951. There are now two classes of fit for B.A. screw threads, sizes 0 B.A. to 10 B.A. To facilitate the economic production of small commercial bolts, screws and nuts, this revision of the 1919 edition provides a "normal" series, having increased bolt and nut tolerances for sizes 0 B.A. to 16 B.A., and affords an allowance, for ease of assembly or for plating, between the maximum bolt and minimum nut sizes. The bolt tolerances included in the previous edition now form a "close" class for more precise engineering, for sizes 0 B.A. to 10 B.A. There is a single series for nuts, this having the increased tolerances. Complete tables are given of basic sizes for sizes from 0 B.A. to 25 B.A.

The specification also includes a recommended gauging system. The main tables are presented in metric dimensions and an appendix repeats the tables in approximate inch equivalents. Other appendices give useful data on the form of the B.A. thread and the basis of B.A. sizes, allowances and tolerances. A useful memorandum has been prepared explaining the relationship between existing gauges, made to comply with the limits specified in B.S. 93 and the War Emergency Amendment of 1940, and the revised specification. The memorandum, which will be issued with the new standard, states clearly with comparative tables the extent to which B.A. gauges may still be used to gauge components complying with the revised limits and tolerances. Price 2s. post free.

ALTERNATING-CURRENT RELAYS FOR RAILWAY SIGNALLING

No. 1745 : 1951. It has been found desirable to revise the series of British Standards for relays for railway signalling and the opportunity has been taken to combine in this standard the provisions of B.S. 520, "Alternating-Current Track Relays" and B.S. 557, "Alternating-Current Line Relays," since many of the provisions of these two standards were similar. The new standard applies to alternating-current line and track relays of the induction type intended for use in railway signalling circuits not exceeding 250V, and is applicable to relays with or without a local element. Price 2s. post free.

MICROMETER HEADS

No. 1734 : 1951. This British Standard for micrometer heads is an addition to the series of standards for engineers' precision tools and may be regarded as complementary to B.S. 870, "External Micrometers." It is a further development of work which was done in connection with the revision of that standard. The new standard relates to micrometer heads supplied independently for assembly with measuring tools or machine tools and applies to three kinds having measuring ranges of ½in, 1in, 13mm, and 25mm and thimble diameters below 1in, 1in and below 2in, and 2in and over. General requirements for the component parts of the head are given and dimensions, graduations and standards of accuracy are prescribed. Price 2s. post free.

BEVEL PROTRACTORS, OPTICAL AND MECHANICAL

No. 1685 : 1951. This British Standard for bevel protractors forms a new edition to the series of standards for engineers' precision tools. It relates to three mechanical kinds and one optical kind of bevel protractors. Standards of accuracy are prescribed for the body, stock and blade of the protractor and for the acute angle attachment, when provided. The method of graduating both types is specified, and general requirements in respect of material, workmanship and marking are included. Price 2s. post free.

Technical Reports

A Bibliographical Survey of the Development and Use of Substitute Materials for Non-Ferrous Metals and Alloy Steels in Germany (Report No. RMS-2). Compiled by the Technical Information and Documents Unit, D.S.I.R. H.M. Stationery Office. Price 1s. 6d.—The demand for many metals, both imported and home produced, has recently outstripped supply, and shortages are likely to prove a problem for a great number of industries in this country. Before and during the war Germany was in the same position. The Germans were forced to find substitutes for such metals as tungsten, copper, tin, nickel, and lead for a wide variety of jobs, and they were very ingenious at doing so. This survey of German documents deals with research and development on substitutes for non-ferrous metals and alloy steels. The survey consists of short summaries of the more useful papers and is made up from intelligence reports and captured German documents. The sections covered are:—Substitute materials for bronze and white metal bearings; substitute materials for electric cable covers and sheaths; alloy steels developed to avoid the use of metals in short supply; surface coatings for steel, especially those which can replace tinning or galvanising; general substitution and new manufacturing processes developed to conserve scarce materials; food cans and containers developed to avoid the use of tin; substitutes for tungsten in sintered carbides for tipped tools and dies; steel cartridge cases (to replace brass).